FOOD TECHNOLOGY

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July, 1957 Volume 11, Number 7

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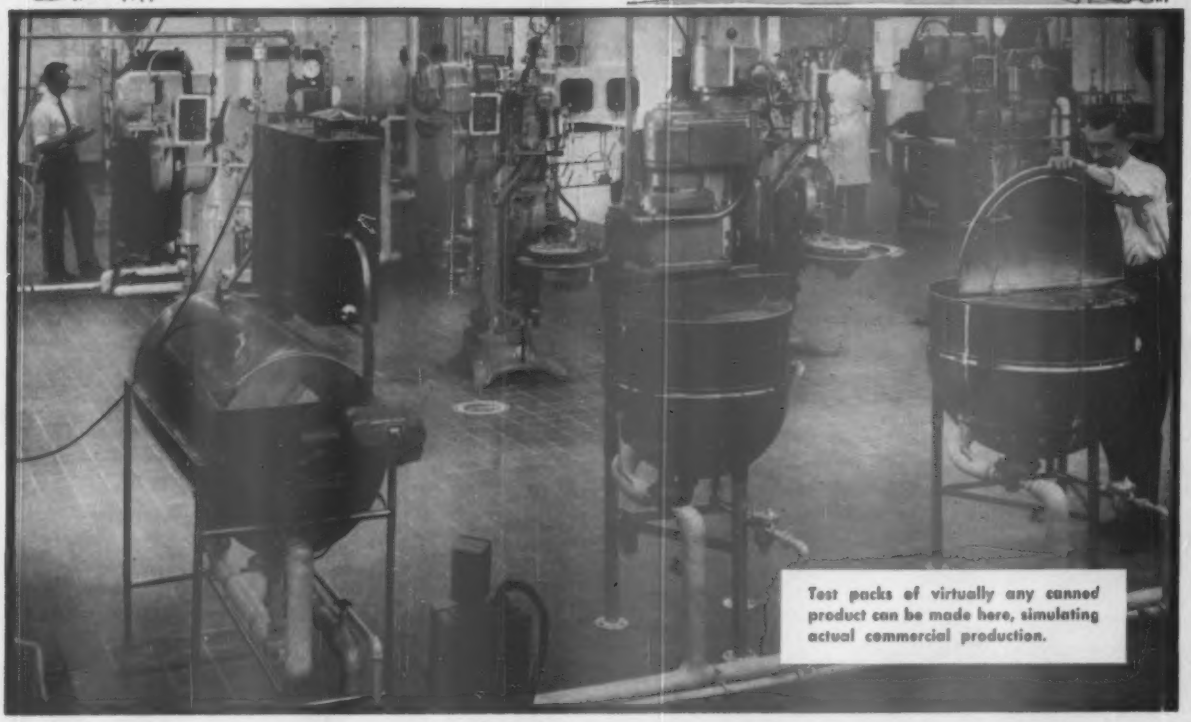

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Foods for the Spaceman[a]

John H. Kilbuck[b]

SOMETIME DURING the International Geophysical Year of 1957–58, we will actually see a great technological step taken in the launching of the first of a number of satellites that will circle the earth, if not completely outside the atmosphere, certainly in its outermost fringes. These first American satellites will be launched by the Defense Department—more specifically, by the Navy. The next obvious step is manned satellites or space flight.

With the ever-increasing technological advancements being made in the development of rockets and in solving their problems of logistics, certainly space flight can not be far away. But it is becoming more and more evident that the human organism is one of the important limiting factors in determining the feasibility of such flights.

John H. Kilbuck . . . Addressed Southern California Section on Foods for Space Travel

Several problems relating directly to man must be solved before spacemen can climb aboard a missile for a trip outside our atmosphere. One is the psychological problem of men in close confinement for weeks or months. This is not a new problem and much has been learned from extensive studies made on groups such as submarine crews. Tests to screen and select individuals capable of tolerating confinement have been developed and methods for maintaining morale in such instances have been studied.

Effect of absence of gravity on an individual's performance is another problem of great importance to space flight. Factors affecting orientation at zero-gravity are being studied with difficulty since this environment is difficult, if not impossible to duplicate on the earth's surface for any appreciable time. But movies made of test animals during the few seconds at the top of a rocket's trajectory showing some loss of orientation during this period confirm the need to develop a means to maintain orientation at all times.

Prime logistical factors—water, food, atmosphere

Leaving the matter of propulsion fuel to the chemists and engineers, the logistics of such a flight can be simplified into three components: water, food and atmosphere.

The problems of living in a satellite during extended space flight have many things in common with life aboard a submarine—especially life aboard our new nuclear-powered submarines. One major difference is that weight reduction is not as important on a submarine as on a satellite. To illustrate—engineers calculate that it takes about 10 pounds of added fuel, structure and equipment to carry one added pound of pay load in a modern high-speed aircraft. This ratio of 10–1 increases tremendously when one contemplates flight to outer space. So several hundred pounds of food and water could make a tremendous difference in the size of such a satellite—even how soon such a flight may become feasible.

Water. Dr. Nello Pace, physiologist at the University of California, has reported that a normal individual engaged in mild activity in a cool, comfortable temperature environment has a water turn-over of about 2½ liters per day. Of this roughly half is lost in alimentary and renal excretions and the other half as insensible perspiration or direct loss of water vapor from the surfaces of the skin and lungs. This represents an irreducible minimum water consumption in one form or another, of 5–6 pounds per man per day. Therefore it becomes of practical importance to devise a system for recycling water through the space man, not only to conserve water but to avoid discomfort of continuous existence in an atmosphere saturated with water vapor.

Food. The food problem is a major one for two reasons— the minimum weight problem and the preserved food problem. On the basis of caloric requirements alone, for an individual engaged in mild activity, using 2,500 calories per 24 hours, the dry weight of pure carbohydrate, protein, and fat that he must consume is of the order of 550 grams—or over 1 pound per day. This is the most concentrated food pill theoretically possible, and a difficult one to swallow if divided into ten pills—impossible to swallow whole. Even with the most advanced dehydrated foods and packaging techniques of today and observing minimum palatability, the daily weight requirements go up to well over two pounds per day.

However, it turns out that we food technologists have not yet solved the problem of a completely preserved ration that can be tolerated for longer than a month or two. Some fresh or frozen food must be added to the diet to maintain acceptability of the ration —thereby accentuating the weight requirements for food alone. Several specific examples can be cited to illustrate this point.

Early in 1953 the Army Medical Nutrition Labora-

(Continued on page 5)

[a] Presented before the Southern California Section of IFT, January, 1957.

[b] Formerly with Office of Naval Research, Research Director of Dried Fruit Ass'n of California. Presently with Wm. J. Stange Co., Oakland, Calif.

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(Continued from page 2)

tory conducted an extremely well-planned cold weather test in Wyoming to determine the ability of large quantities of B-complex vitamins and vitamin C to increase resistance to cold. Very complete records were kept of each of the 87 subjects' food intake. It was planned that during each stage of the test, their intake should contain a definite quantity of protein, fat, and carbohydrate. A large portion of the proteinaceous intake was to have come from the canned meat items in the regular "C" ration. After a few weeks of this diet, it became apparent that it would be necessary to change to fresh meat as a replacement for the meat items of the "C" ration to maintain the desired protein intake level since the subjects were not eating the canned meat items. This was done at the end of the fifth week. Quoting from the AMNL Report, they report, "It will be noted that the return rate for the canned meats increased progressively and reached substantial proportions by the fifth week. Rejection of vegetables, and to a lesser extent fruits, also increased somewhat during the 5 weeks; however, when fresh meats were substituted for canned meats in the 6th week, the acceptance of fruits and vegetables improved."

Similar experiences have been noted prior to and since these tests. Several years ago a group of California mountain climbers and scientists attempted to climb Makalu—the fourth highest mountain in the world—near Everest. Of course, in an expedition of this nature where they had to hike about 150 miles to reach the base of the mountain, weight of food is important. But they still carried canned meats and fish and cured meats. Members of that expedition report increasing unacceptance of their meats and stews. The only way they could make stew or a meat dish palatable, they report, was to kill a ptarmigan-like bird and add it to their meat. Then they had a delicious dish.

Many ex-servicemen probably remember the aversion to luncheon-meat products during World War II. Eaten infrequently it is an excellent product but when it is eaten regularly for extended periods of time it becomes quite unacceptable. But here was a case in which a food may have appeared too often on the menu. Certain foods, but only a few, are continuously acceptable when eaten regularly in small amounts but become unacceptable when included on the diet in large amounts. Eggs are a good example. No food is more highly prized nor more acceptable than eggs when ingested in limited quantities. When eggs are eaten in amounts that make up 5% of the caloric intake they may be eaten indefinitely. But most people tire of them when they make up 10% of the diet.

Atmosphere. A proposed solution to the atmosphere problems within the satellite may assist in solving the problem of continued acceptance of processed foods.

In order for aircraft to exceed altitudes of 50,000 feet it is essential to provide a sealed chamber in which an atmosphere of suitable composition and pressure can be maintained. For relatively short flights, such as are made by the new jet planes of today to altitudes of 100,000 ft. or more, the problem has been a simple one to solve by compressing the surrounding thin air to the

proper pressure or by carrying cylinders of compressed oxygen. But when the oxygen is left behind and long periods of time are involved, the problem of carrying enough compressed gas becomes a very serious one. In addition, provision must be made for removing the CO_2 produced by body metabolism. Chemical sources of oxygen, such as peroxides, might be expected to serve a useful application here, but all attempts to date with chemical methods have been disappointing because of such difficulties with side reactions that yield undesirable toxic products, inefficiency of the reactions, and bulk of reactants.

Photosynthetic systems a promising solution

By far and away the most promising solution at present seems to be the development of the photosynthetic system utilizing green plants, such as algae. This was proposed 15–20 years ago by science-fiction writers, since they knew that green plants would remove the CO_2 produced by space man and restore the oxygen that he consumes.

That this is feasible is readily demonstrated theoretically and is strongly suggested practically by the success of using algae in sewage disposal processes. Also research projects have been supported by Government agencies, for example, one by the ONR, to explore the practicability of a photosynthetic system for the renewal of stale atmospheres.

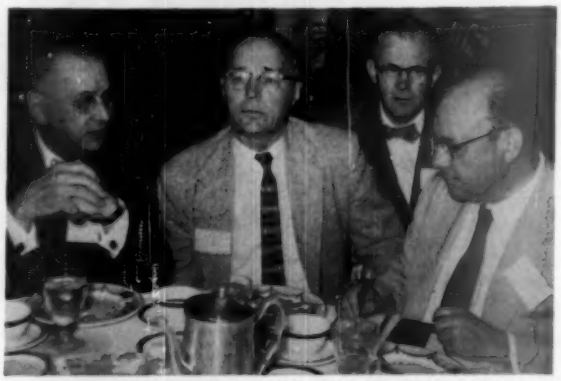
Such a system would fit into the food picture in that the plant material could serve as a dietary supplement as the plants grow. The importance of having fresh plant material available cannot be overemphasized.

To investigate such problems as the continued acceptance of processed foods, causes of monotony of certain foods and ability of certain foods to give a feeling of satiety, to list a few, requires the combined efforts of food technologists and nutritionists. That our Government, through several agencies, is spending millions of dollars on these and similar problems is good evidence of their importance. For until more is known about these problems man will find it difficult to maintain nutritional well-being without the ingestion of some fresh or fresh-frozen foods, whether it be in a space missile or during an isolated military operation.

PITTSBURGH "CANADIAN BREAKFAST" GREATEST EVER

This year's IFT National Convention was only a day old when it was learned that the accommodation arranged for the "Canadian Breakfast" would be insufficient for the number attending. In all, 62 persons were present, 41 being IFT members from Canada while the remaining 21 consisted of IFT officials, American friends, and Canadians now residing in the United States.

Greetings were brought from the National IFT by retiring President George F. Garnatz. He said that he was attending the "Canadian Breakfast"—as he had also done last year in St. Louis—not as a matter of duty, but of choice. He also expressed the hope that he would be eligible to become an Alumnus member of the Canadian group. Incoming President Emil M. Mrak said that he was attending "by choice" also; he referred to his recent visit with the British Columbia IFT Section when he was impressed by a well-attended meeting and wound up his remarks saying that he hoped to do some salmon fishing with Vancouverite, Dr.



Past, Future, Present: L. to r.: Dr. Garnatz, Dr. Olsen and Dr. Mrak with Bob Marshall, "Canadian Breakfast" Chairman, doing the eavesdropping.

Head Table Celebrities: L. to r.: Col. Lawrence, Dr. Tarr and Dr. Cook.

Three of a Kind: L. to r.: H. C. Aitken (Breakfast Chairman, 1957-58), A. H. Jones and H. P. Stevens.

Hugh Tarr, newly-elected IFT Councilor. President-elect Aksel G. Olsen took a bow as did IFT Treasurer Ray Wakefield, bringing friendly greetings, while IFT Executive Secretary Charles S. Lawrence told how much he enjoyed meeting with the Canadians; in fact he had yet to miss a Canadian Breakfast.

H. G. Aitken, Canada Vinegars Ltd., Toronto, succeeds R. B. Marshall, H. J. Heinz Co. of Canada Ltd., Leamington, as Chairman of the Canadian Breakfast,

(Continued on page 14)

PROVERB PRATTLE

"Two heads are better than one"

Aristotle, about 330 B.C., in "Politics" says: "Two good men are better than one." An ancient Chinese proverb shows a similar intent with: "One man sees short, two men see long." In 1546, John Heywood quotes the proverb as it is popularly known.

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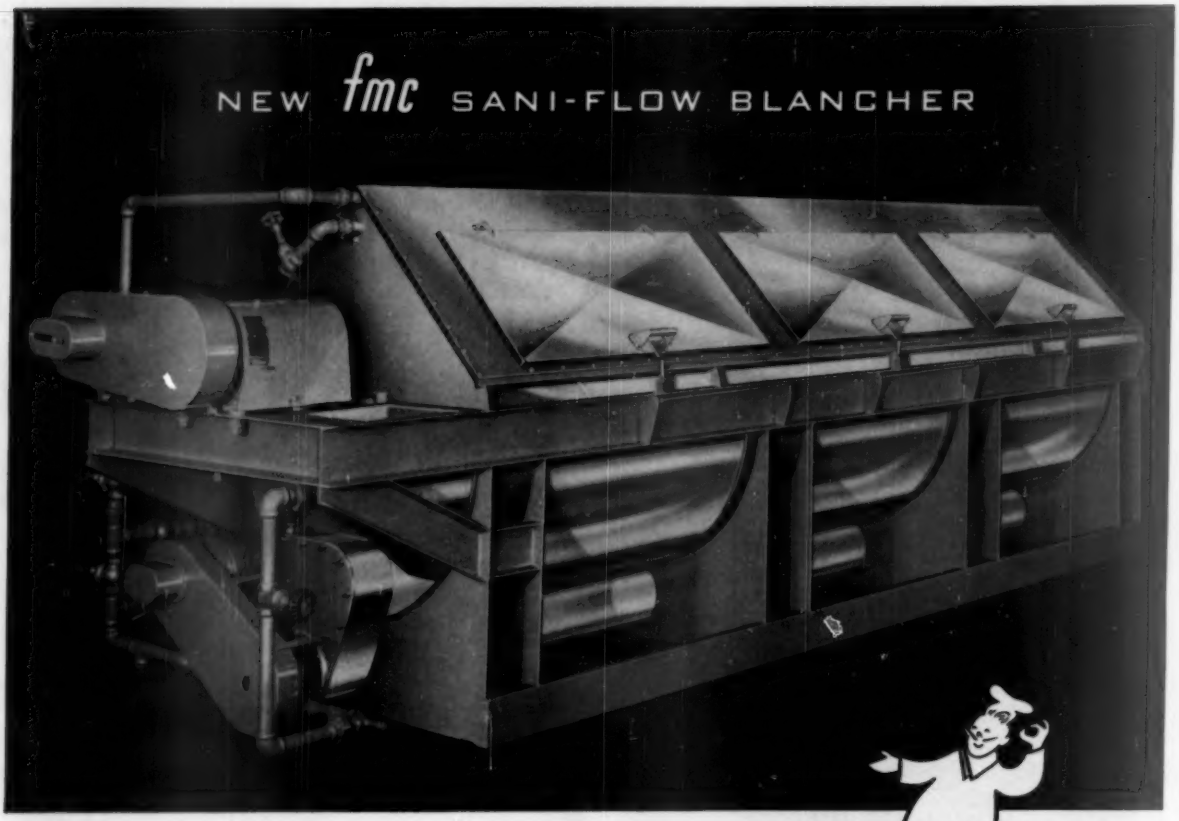

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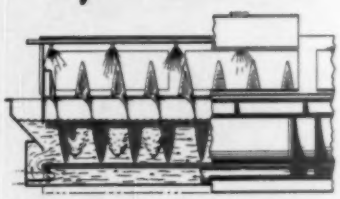

This is no ordinary screw conveyor. It is carefully fabricated and machined to maintain an extremely close tolerance with the shell. Channeling is avoided. Screw acts as timing device for controlling the through-put rate of the product.

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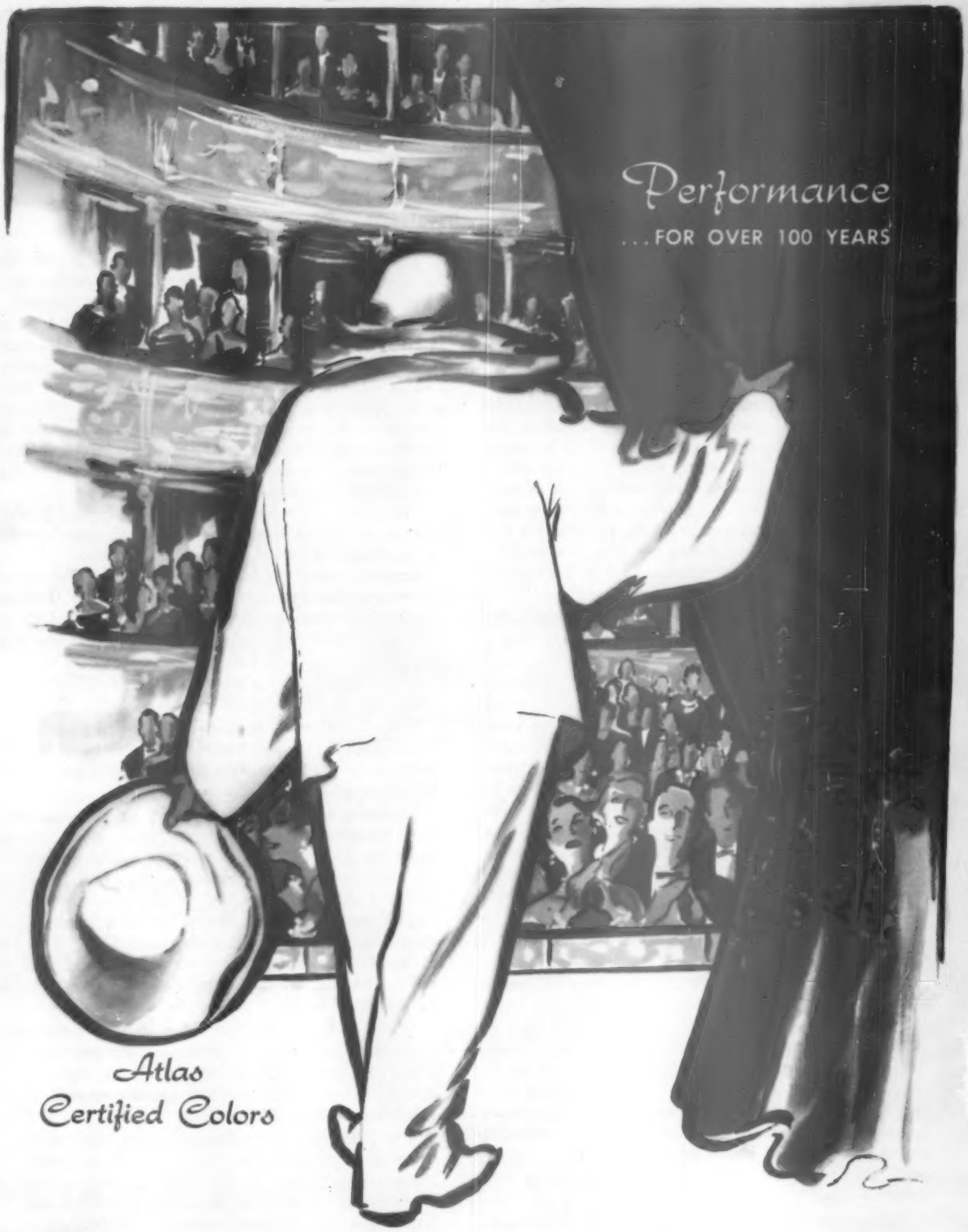

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IFT ACTIONS AND REACTIONS...

Fats and Fads in Eating Pork

Rita Campbell
Director, Department of Nutrition, National Live Stock and Meat Board

FOR MANY YEARS there has been an unconfirmed idea that pork is less digestible than other meats, that its keeping quality is limited, and that it is high in calories and therefore fattening. Because of these factors, the erroneous idea developed that pork should not be fed to young babies, pregnant women, senior citizens and calorie-conscious individuals. Its use in the post-operative diet also is frequently restricted.

Pork when consumed (with its fat trimming) is likely to be digested more slowly than other meats. In certain cases this may be a desirable factor. It is possible that digestibility and satiety value (appetite satisfaction) of foods is sometimes confused. Fat is as well digested as carbohydrate and protein and possibly better digested. The variability in calorie value which the consumer may have when she selects pork is desirable. Because of this, pork is a valuable food in the weight gaining or reducing diet.

The pork in the retail market today is a markedly different product than it was 30 to 40 years ago. Great improvements have been made in the fields of merchandising, packaging and distribution of this product. In addition, the pork being marketed today is from leaner, meatier hogs and shows less fat than has been the case previously. Many weight-conscious individuals are removing any excess fat from pork as it is served at the table. Moreover, external fat on pork cuts is being trimmed more closely at both the packer and retail levels. A study was recently completed on the protein, fat and calorie value of today's pork products as they are eaten. It showed that pork, as well as beef and lamb, has fewer calories, less fat and more protein than it has been getting credit for.

PORK IN THE WEIGHT CONTROL DIET

The trend over the years has been to recommend a high protein diet—featuring lean meat. Today, however, the tendency is toward a diet which is high in protein and contains a moderate amount of fat. Therefore, the meat included in a reducing diet need not be excessively lean. Dr. Charlotte Young of Cornell University is currently conducting research on this subject and reports that this moderate fat diet is highly effective and satisfying. The liberal amount of thiamine which pork also provides is another reason for including it in reducing diets.

With regard to general consumption of pork, it may be stated that it is a satisfactory food for young babies 4 to 6 weeks of age. It is popular with young children and an ideal food for the adolescent. During the prenatal period when nutritive needs are increased, pork is highly recommended as a source of protein, B vitamins, iron and phosphorus.

PROTEIN TO PREVENT HEART DISEASE

At the present time, the number one health problem for the middle-aged American man is atherosclerosis. Here again diet, and fat particularly, is frequently implicated. This disease is characterized by an accumulation of cholesterol in the arteries which eventually may cause blocking and fatality. The cause of this accumulation of cholesterol and methods of dislodging it once accumulated have to date not been determined. Another problem in this connection is the level of cholesterol in the blood and its relation to diet. Several experimental animals have been used in these studies including chicks, rats, guinea pigs, dogs and monkeys.

One theory in connection with this disease is that protein or certain essential amino acids may prevent accumulation of cholesterol in the arteries.

Several researchers have concentrated on the role of fat in atherosclerosis. These include Ralph Holman, Ph.D. of Hormel Institute. Holman's studies indicate that when there is a high cholesterol level in the diet, the intake of essential fatty acids may prevent damage. Lard is a source of the unsaturated fatty acids and therefore may offer some protective value.

F. A. Kummerow, Ph.D. of the University of Illinois, has emphasized the fact that cholesterol is manufactured in the body and that the amount consumed normally in food is not a hazard.

However, cholesterol in the body may be manufactured by dietary carbohydrate. Kummerow has investigated the possibility that a high protein diet may reduce cholesterol synthesis in the body. In addition, he has reported that hydrogenation of fats results in formation of trans-acid forms which may not be as readily metabolized as lard and natural fats. Therefore, more of these hydrogenated fats may be retained in the body and deposited in arteries and therefore be hazardous to health.

Fredrick Stare, M.D., Ph.D., another outstanding researcher, believes that atherosclerosis may be a nutrition problem. He has developed atherosclerosis in monkeys whose diets do not contain enough of the sulphur-containing amino acids.

Dr. Stare has also emphasized the role of certain types of fat in increasing the level of blood cholesterol. Again reports indicate that hydrogenated fat may be more damaging than soft fats such as lard and oils. Dr. Stare has also reported results of injections of fat emulsions in patients with cardiovascular disease as compared with normal patients. Although the blood levels took a longer period of time to return to normal in ill patients than in normal patients, they continued to fall after fat infusions had been given. The reason that

(Continued on page 12)

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(Continued from page 10)

these fat infusions reduce the blood fat level is not known.

Dr. Stare and his research group have continually emphasized the importance of maintaining normal weight and the role of exercise in preventing this condition.

THE ROLE OF FATS IN SKIN HEALTH

On the positive side, we find that the role of essential fatty acids in human nutrition is gaining in importance. Dr. Hansen, at the University of Texas, Medical Branch, is continuing to study the relationship of essential fatty acids to the health of the skin. Recently, Dr. Hansen has reported that more calories may be needed on a low fat diet than on one which contains a moderate amount of fat: thus the moderate fat level being recommended by Dr. Young and others seems logical.

PROTECTION AGAINST RADIATION

Studies with experimental animals have indicated that unsaturated fats such as lard and oils have a protective effect when animals are exposed to radiation.

Fat supplies in many parts of the world are extremely limited. Few studies of fat deficiency conditions have been made but undoubtedly the widespread deficiency conditions which exist in these areas are in part related to the inadequate fat supply.

However, Stare reports that in the United States the per capita fat intake has increased from 134 to 148 grams per day from 1935 to 1955. This may be partially due to an increased consumption of meat, milk and eggs and a decrease in cereal and potato consumption. In the average American diet, fat supplies from 36 to 46 percent of the total calories. Of this amount, approximately 70 percent is from animal and 30 percent from vegetable sources.

In general, fat increases the palatability of food and insures the intake of nutritious foods. Also it gives satiety value to the meal. A meal which contains fat stays with a person longer than one which supplies less fat. This may be due to the slower digestibility of fat. Although digested almost completely, fat is digested more slowly and therefore provides a greater feeling of satisfaction than food of similar calorie value but lower in fat.

The satiety value of fat is one reason that a reducing diet which contains a moderate amount of fat has been found to be highly effective.

Researchers have also warned against the dangers of a too low fat intake. Symptoms such as stomach and intestinal upsets, depression and irritability may follow fat restriction, according to Dr. Irvine H. Page, of Cleveland, Ohio, an authority on cardiovascular disease. The trend toward a reduced fat and lower protein intake may produce undesirable nutritional deficiencies.

Pork has long been known to be one of the outstanding dietary sources of thiamine and now another factor has been discovered in pork. Research under the direction of C. A. Elvehjem, Ph.D. at the University of Wisconsin, indicates pork muscle protein has a protective effect in animals that have been exposed to stress. This protective factor in pork has not as yet been identified. Pork is superior to casein in this connection. Animals fed as high as 42 percent pork protein survive the 60 day period whereas basal animals fed casein died after an average of 30 days. Pork muscle has a favorable effect on the liver enzyme system which may be altered during hypothyroidism. More research is needed to isolate this protective factor in pork and investigate its action.

In summary, the role of pork and fat in nutrition is very much in the limelight today. Further research into the problem of atherosclerosis with regard to diet and fat particularly, may actually strengthen the role of high quality protein foods such as pork which also provides other dietary essentials. Research is also needed into the role of essential fatty acids in the health of the skin. Many of the fads and misconceptions with regard to pork have been overcome. Education is continually needed to counteract misinformation about pork and fat in general. More emphasis should be placed on the positive value of fat as an essential nutrient and as our most efficient source of energy.

PRESIDENT EMIL MRAK TAKES OVER NEW OFFICE

With the highly successful Pittsburgh meeting now a matter of IFT history, the Institute is under way on a new administrative year. President Emil Mrak has moved into the duties of his new office with vigor and with full awareness of the many obligations of the job. Our thriving society of food technologists has increased the scope of its technical interests and multiplied its administrative routines. President Mrak will be engaged, as his predecessor, George Garnatz, was engaged before him, in giving leadership and impetus to the movement to enlist high school and college students of scientific bent in Food Technology as a career, in professionalizing through standing committees our attitude toward food and drug legislation, toward the education of food technologists, toward approaches to food research and technology problems, subjective measurement of food quality, the status of new methods of food preservation, the role of new instruments, and new developments in food machinery, etc., etc. The list of professional interests of IFT grows longer each year.

As President Mrak proceeds through his term of office, it is certain that new problems will emerge and that old ones will take on new urgency. During 1957–58, efforts to get down to the grass roots opinions of what IFT is, whom it serves, what new directions it should take will continue. Efforts to bring the pur-

(Continued on page 14)

One look at the huge, sprawling buildings at one of the Exchange Products plants and you know that big things are happening inside. For here *citrus* is king. Trucks pour in with fresh fruit from groves all over California and Arizona. Conveyer belts hum along in every direction. And Exchange products are shipped to nearly every part of the world.

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(Continued from page 12)

poses of a technical group into ever sharper focus are normal to all professional societies. In IFT, with its strong bonds of professional fellowship, there is an increasing urge toward concentrating our professional energies on a reasonably explicit program of food-centered projects. The task of defining and articulating such a program is a group effort, but the leadership of President Mrak assisted by President-Elect Aksel Olsen will be needed—and freely given.

In Memoriam

JOHN BECKETT, formerly Technical Director of Aseptic-Thermo Indicator Company, passed away last month from a heart attack while in the hospital awaiting surgery for another cause. Mr. Beckett, well known for his work on thawing indicators, was also chairman for one of the Frozen Food Committees activated jointly by the Quartermaster Food and Container Institute for the Armed Forces and The Research and Development Associates of the Food and Container Institute. In 1955 he was Exhibits Chairman of the Institute of Food Technologists Annual Meeting at Los Angeles.

Mr. Beckett was also well known in the Hospital Sterilization field. He was co-author, with Phoebus Berman, M.D., of a widely used book entitled, *Sterilization and Disinfection*, and will be remembered by many as an outstanding authority on sterilization problems.

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REGIONAL SECTIONS

(Continued from page 6)

while Alfred J. Kahn, Food Products Ltd., Montreal, takes over the Secretaryship from Allan H. Klopp, Griffith Laboratories Ltd., Toronto. The following were named to the Liaison Committee: C. Hamilton Kenney, Canada Dept. of Agriculture, Ottawa; H. L. A. Tarr, Fisheries Research Board, Vancouver; a member for Winnipeg has yet to be appointed; and R. B. Marshall and Allan Klopp will serve *ex officio*.

Enjoying themselves: L. to r.: Percy Gitelman, G. H. Goldschmied and Fred Kahn (Secretary, 1957-58).

Breakfast Chairman Bob Marshall reviewed events of the past year and reported that the questionnaire sent to IFT members in Canada resulted in an overwhelming choice of an Eastern Canada location for an IFT National Convention. The Pittsburgh "Canadian Breakfast" unanimously passed a resolution that an invitation be extended to the Institute of Food Technologists to hold its national convention in Montreal in 1965.

GARNATZ WINNER

Gift packages were donated to the "Canadian Breakfast" by the following Canadian firms: Canada Packers Ltd., General Foods Ltd., Griffith Laboratories Ltd., H. J. Heinz Co. of Canada Ltd., W. Clark Ltd., Burns & Co., Canadian Canners Ltd., and Canada Starch Ltd. Winners were outgoing President George F. Garnatz, G. W. Hope, W. A. Breckin, H. C. Aitken, and J. W. Barlow. American guests who won prizes were Dorothy Ann Huber, QM Food & Container Institute, Chicago; George D. Wilson, American Meat Institute Foundation, Chicago; and Leonard P. Worthen, Pillsbury Mills Inc., Minneapolis, Minn.

(Continued on page 22)

Round-table Session. That's John Bowen at extreme right; Larry White, left foreground.

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AWARDS AND HONORS . . .

FELLOWS AND SCHOLARS IN FOOD TECHNOLOGY, 1957

With Dr. Charles G. Ferrari, Technical Director, J. R. Short Milling Co., presiding, the recipients of the scholarship awards for 1957 were announced at the Awards Luncheon, Monday, May 13, at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania. Dr. Ferrari, chairman of the Awards Committee of IFT, called attention to the increasing competition for the scholarship awards and to the outstanding qualifications of this year's winners.

The winners of the Awards together with a brief account of their backgrounds follow:

Florasynth Fellowship, 1957-58

Mr. Michael Ross Gumbmann, candidate for a doctorate at the University of California at Davis, was elected to hold the Florasynth Fellowship for 1957–58.

Native of Salt Lake City, Utah, he attended public schools in that city and in California, entering college in 1948 (Mt. San Antonio Junior College, Pomona) and was graduated from the University of California (B.A., 1953) with highest honors in Biochemistry and further distinguished himself by election to Phi Beta Kappa. Mr. Gumbmann was in the Armed Services from 1953 through 1955 and was stationed at the Army Chemical Center in Maryland. Mr. Gumbmann is working for a Ph.D. in Agricultural Chemistry under Dr. A. L. Tappel, Department of Food Technology, University of California at Davis.

Gerber Baby Foods Scholarships, 1957-58

Yorkette Solomon, finishing her sophomore year at the University of Massachusetts at Amherst, was selected a Gerber Scholar for the year 1957–58. She is majoring in the sciences at the University of Massachusetts and has to her credit two years of chemistry, two of mathematics, and a year each of biology and physics at the midpoint in her undergraduate career. In addition to carrying her curricular work at a high level, Miss Solomon is very active in extracurricular activities. She was voted Most Valuable Member of the Class of '59 and is a member of the University Committee for Student Social Activities.

Ronald K. Tuttle, selected for a 1957–58 Gerber Scholarship, is a student of the University of California at Davis. He has established an excellent scholastic record in his major subject, Food Technology, as well as in Engineering, which subject he is pursuing as an adjunct to his training in the food sciences. In addition to his curricular work, Mr. Tuttle has engaged in a variety of campus activities. He is a member of Alpha Zeta (honorary agricultural fraternity) and chairman of the Program Committee of the Little International Livestock Show. Upon graduation, Mr. Tuttle plans to become a candidate for a Ph.D. in Food Technology with special reference to its engineering phase.

Herbert Sumner Waxman, who will be a senior at the Massachusetts Institute of Technology during 1957–58, is also the recipient of a Gerber Baby Foods Scholarship. Mr. Waxman has attained a high level of scholarship in chemistry, physics, mathematics, and biology as well as in courses in the humanities. His extracurricular activities include participation in campus professional groups (Sedgwick Biological Society, Institute of Food Technologists, etc.) and he was selected for membership in two honorary societies—Scabbard and Blade (military) and Phi Lambda Upsilon (chemistry).

General Foods Fellowships, 1957-58

Edmund Lusas, presently studying at the University of Wisconsin under the direction of Dr. K. G. Weckel of the Department of Dairy and Food Industries, was re-elected to hold the General Foods Fellowship. During his incumbency of the 1956–57 Fellowship,

(Continued on page 18)

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(Continued from page 16)

Mr. Lusas began work on his Ph.D. project—the stability of anthocyanin pigments in beets. He will continue work on this problem during 1957–58.

JOHN V. SPENCER, winner of a General Foods Fellowship for 1957–58, will pursue a graduate project on factors affecting the flavor of poultry meat, at Purdue University, Lafayette, Indiana. Ultimate aim of his work is to develop an objective method for the determination of poultry meat flavor. Mr. Spencer has had three years of training at the University of Washington in the biological sciences, holds a B.S. and an M.S. degree in Agriculture from the State College of Washington, and has been a research assistant and also an instructor in that institution since 1953. Mr. Spencer has published widely in his field and has authored or co-authored several articles appearing in FOOD TECHNOLOGY and FOOD RESEARCH.

HARRY ELLSWORTH SNYDER was graduated from the University of California in 1951 and immediately thereafter was commissioned in the U. S. Navy. He served for three years aboard the U.S.S. Los Angeles, a ship in the heavy cruiser class. He is presently registered as a graduate student in Microbiology at the University of California at Davis. He will utilize his General Foods Fellowship in support of his work toward a Ph.D. His project is the enzymatic breakdown of inulin by *Saccharomyces fragilis*. The results should assist in elucidating the enzymatic hydrolysis of carbohydrates.

Samuel Cate Prescott Award, 1957-58

ROBERT E. HUGHES, JR. has the distinction of being the initial winner of the Samuel Cate Prescott Award. A graduate student at the University of California, Davis, he is presently a candidate for the Master's degree. He is a graduate of Oregon State College, where he won many academic distinctions (Phi Sigma, Phi Mu Epsilon, the Ernest H. Wiegand Award). Mr. Hughes plans to pursue graduate work beyond the Master's and to seek a Ph.D. or a D. Sc. degree in one of the food sciences.

International Award, 1957

Sponsored by the Australian Regional Sections of IFT this honor is bestowed upon a member of the Institute who has promoted "the international exchange of ideas in the field of Food Technology, thus contributing to international understanding." The International Awardee for 1957 was DR. LAURENCE V. BURTON, who, through his writings and through missions overseas, eminently qualifies for this distinction. Dr. Burton, presently a consultant residing at Scarsdale, New York, was for many years Editor of FOOD INDUSTRIES. More recently, but now retired from this position, he was Executive Director of the Packaging Institute, Inc. During World War II he was consultant for the Armed Forces on overseas packaging problems, with a special assignment in Australia and the South Pacific regions generally.

The Babcock-Hart Award, 1957

The Nutrition Foundation, Inc., Sponsor

High honors at the Awards Luncheon went to the distinguished recipient of the Babcock-Hart Award, DR. ELMER M. NELSON. (See the May issue, FOOD TECHNOLOGY.)

The Award was presented by Dr. L. E. Clifcorn, past president of the Institute, who cited Dr. Nelson's outstanding contributions to human nutrition and his distinguished public service as Chief, Division of Nutrition, the Food and Drug Administration, U. S. Department of Health, Education, and Welfare.

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SELECTED ABSTRACTS . . .

Compiled by H. A. Campbell

ANALYTICAL METHODS

A rapid quantitative analysis of collagen. *Lab. Practice, 6,* 111–12 (1957).

A method for measuring the amino acid content of collagen was developed by the Natl. Bureau of Standards leather lab. The procedure is an application of two-dimensional paper chromatography. The quant. technique can be applied not only to collagen, but also to the deriv. and degradation products of collagen. It enables the analyst to follow with a high degree of detail the reactions and changes in which collagen may be involved. It is a useful tool in understanding the structure of collagen.

BIOLOGICAL SCIENCES

BIOCHEMISTRY

The mode of action of pancreatic carboxypeptidase. I. Optical and structural specificity.

YANARI, S., AND MITZ, M. A. (Armour and Co., Chicago, Ill.). *J. Am. Chem. Soc., 79,* 1150–3 (1957).

It is concluded that not only the C-terminal residue of a polypeptide but also the adjacent amino acid residue must be oriented stereospecifically at the active site of the enzyme for optimal activation.

The effect of ingested chlortetracycline on some hydrolases and organs associated with the digestive process in growing pigs. II. Pancreas-dry weight, fat content, protease, and amylase activity.

VONK, M. A. A., MCELROY, L. W., BOWLAND, J. P., AND BERG, R. T. (Univ. of Alberta, Edmonton, Canada). *Can. J. Biochem. & Physiol., 35,* 187–93 (1957).

Chlortetracycline fed at a level of 20 g./ton of feed caused an increase in rate of gain and efficiency of feed utilization. There was an increase in the dry wt. of the pancreas, total protease and amylase activity, and amylase activity per gram of dry matter. No difference in the crude fat content of the pancreas was found.

Chemical effects of ionizing radiation on proteins. I. Effect of γ-radiation on the amino acid content of insulin.

DRAKE, M. P., GIFFEE, J. W., JOHNSON, D. A., AND KOENIG, V. L. (Quartermaster Food and Container Inst. for the Armed Forces, Chicago, Ill.). *J. Am. Chem. Soc., 79,* 1395–401 (1957).

The study was undertaken to det. the radio-sensitivity of the constituent amino acids of a protein in order to provide information which might indicate the source of objectionable qualities of aroma and flavors that have been found to occur in the sterilization of food proteins by ionizing radiation. One % insulin in basic (pH 8.5) and in acidic (pH 3.0) solns. was subjected to 0, 10, 20 and 40 million r.e.p. γ-radiation doses. Cystine, tyrosine, phenylalanine, proline and histidine are demonstrated to be very radio-sensitive. Leucine, valine, lysine and arginine are significantly destroyed at the high irradiation dose level. The N-terminal amino acids of insulin, glycine and phenylalanine, are shown to be deaminated. Cysteic acid is identified in the hydrolyzates of the irradiated insulin. An increase in mol. size of the irradiated insulin is reported.

Utilization of peptides in protein synthesis.

MEDVEDEV, Z. A. (Moscow Agr. Acad., U.S.S.R.) *Biokhimiia, 21,* 288–92 (1956); *Intern. Abstr. Biol. Sci., 5,* No. 3871 (1957).

C^{14} proteins from the leaves of *Galega orientalis,* pea leaves and yeast were partially (pancreatic secretion) and completely (pepsin) hydrolyzed, the resulting hydrolyzates being subsequently infiltrated into leaves or added to the yeast nutrient medium. Protein synthesis proceeded at about the same rate for both hydrolyzates in the leaves (rate was smaller for the pancreatic hydrolyzate in yeast). The rate of CO_2 evolution, however, was 2–7 times higher in the complete hydrolyzate, indicating that peptides in the pancreatic hydrolyzate are incorporated into protein mols. without previous breakdown into simple amino acids.

The biological oxidation of sorbitol.

CUMMINS, J. T., KING, T. E., AND CHELDELIN, V. H. (Oregon State Coll., Corvallis). *J. Biol. Chem., 224,* 323–9 (1957).

The oxidation of sorbitol by sol. exts. of *Acetobacter suboxydans* proceeds by two pathways, depending upon which pyridine nucleotide is present. In the presence of triphosphopyridine nucleotide, sorbose is formed. In the presence of diphosphopyridine nucleotide, fructose is produced. The fructose can then be phosphorylated or further oxidized by cell-free exts. These two newly defined pathways occur in addn. to the previously demonstrated sorbitol dehydrogenase which is found in the particulate fraction of the cells.

Function of the essential fatty acids. *Nutrition Revs., 14,* 345–7 (1956).

The occurrence of the double bond in these acids, coupled with the knowledge that many biol. oxidation-reduction reactions are dehydrogenations, has led to the belief by some that the essential fatty acids are vital in H transfer reactions. The data on this subject is reviewed especially as regards the enzymes of terminal respiration and oxidative phosphorylation.

MICROBIOLOGY

The relationship between bacteriophages of Salmonellae and their O antigens.

SILLIKER, J. H., AND TAYLOR, W. I. (Research Labs., Swift & Co., Chicago, Ill.). *J. Lab. Clin. Med., 49,* 460–4 (1957).

(Continued on page 380a)

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REGIONAL SECTIONS

(Continued from page 14)

ROLL CALL

Toronto: W. A. Breckin, E. J. Dufault, H. R. Nordin—Canada Packers Ltd; J. W. Wenzel, A. H. Klopp, J. A. Ziegler—Griffith Laboratories Ltd.; P. Gitelman, Food Colors Ltd.; H. C. Aitken, Canada Vinegars Ltd.; W. R. Mason, General Foods Ltd.; Ray Pearen, Canada Starch Ltd.; W. R. Smithies, Defence Medical Research Board; and Tom Keefe, Stange-Pemberton Ltd. *Leamington:* R. B. Marshall, C. B. Coyle, K. F. Shaw—H. J. Heinz Co., of Canada Ltd. *Hamilton:* Larry White, Canadian Canners Ltd. and H. P. Stevens, American Can Co. *Guelph:* S. F. Lewis, Matthews-Wells Ltd. and E. W. Franklin, Ontario Agricultural College. *Brantford:* G. Williamson and D. H. Riddols, York Farms Ltd. *St. Catharines:* J. A. Jackson and R. W. Alexander, Wethey's Ltd. *Ottawa:* A. H. Jones, E. Asselbergs, C. Hamilton Kenney—Canada Dept. of Agriculture; W. H. Cook, National Research Council; Keith Torrie, Pure Spring Ltd.; J. H. Mahon and Constance Anglin, Canada Dept. of National Health and Welfare Food & Drug Division. *Oakville, Ont.:* K. G. McPhee, Chocolate Products Ltd. *Vancouver:* H. L. A. Tarr, Fisheries Research Board of Canada. *Montreal:* A. J. Kahn, Food Colors Ltd.; J. W. Barlow, T. J. Lipton Ltd.; G. H. Goldschmied, McLean's Food Products Ltd.; Peter Smith, Rose & Laflamme Ltd.; A. E. Crawford, W. Clark Ltd.; and G. Krivchik, Florasynth Laboratories Ltd. *Kentville, N. S.:* G. A. Hope and L. Townsend, Canada Dept. of Agriculture Experimental Farm. *Summerland, B. C.:* John Bowen, Canada Dept. of Agriculture Experimental Farm.

The Penn-Sheraton's Grant Room was filled to capacity by the "Canadian Breakfast." Constance Anglin and Dr. Mahon in center foreground.

Sideview. John Wenzel and Peter Smith in center foreground.

C. HAMILTON KENNEY
Associate Editor
FOOD TECHNOLOGY

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INDIANA . . . .

The Section held its May meeting at Turners' Athenaeum in Indianapolis. The forty-four members and guests enjoyed a pleasant social hour followed by a turkey dinner in the Blue Room.

The results of the election were reported, and the following are officers for 1957–58.

Chairman—Seb Davin, Wm. J. Stange Co.
Chairman Elect—Lee Truman, Pest Control Service
Secretary-Treasurer—Verna McCallum, Stokely-Van Camp
Directors—George Clark, Stokely-Van Camp and William Klinker, Eaton Canning Company

Dr. Emil M. Mrak, National president and our guest speaker, presented awards to Miss Judy Ahring and Mr. Bruce Schelegel. These two Broad Ripple High School students were the winners of the essay contest held in association with our High School Career Day program. Miss Betty Rosenberry of the Broad Ripple faculty was also a guest for this event.

Dr. Mrak proceeded to give a brief history of the development of food research. He then outlined some

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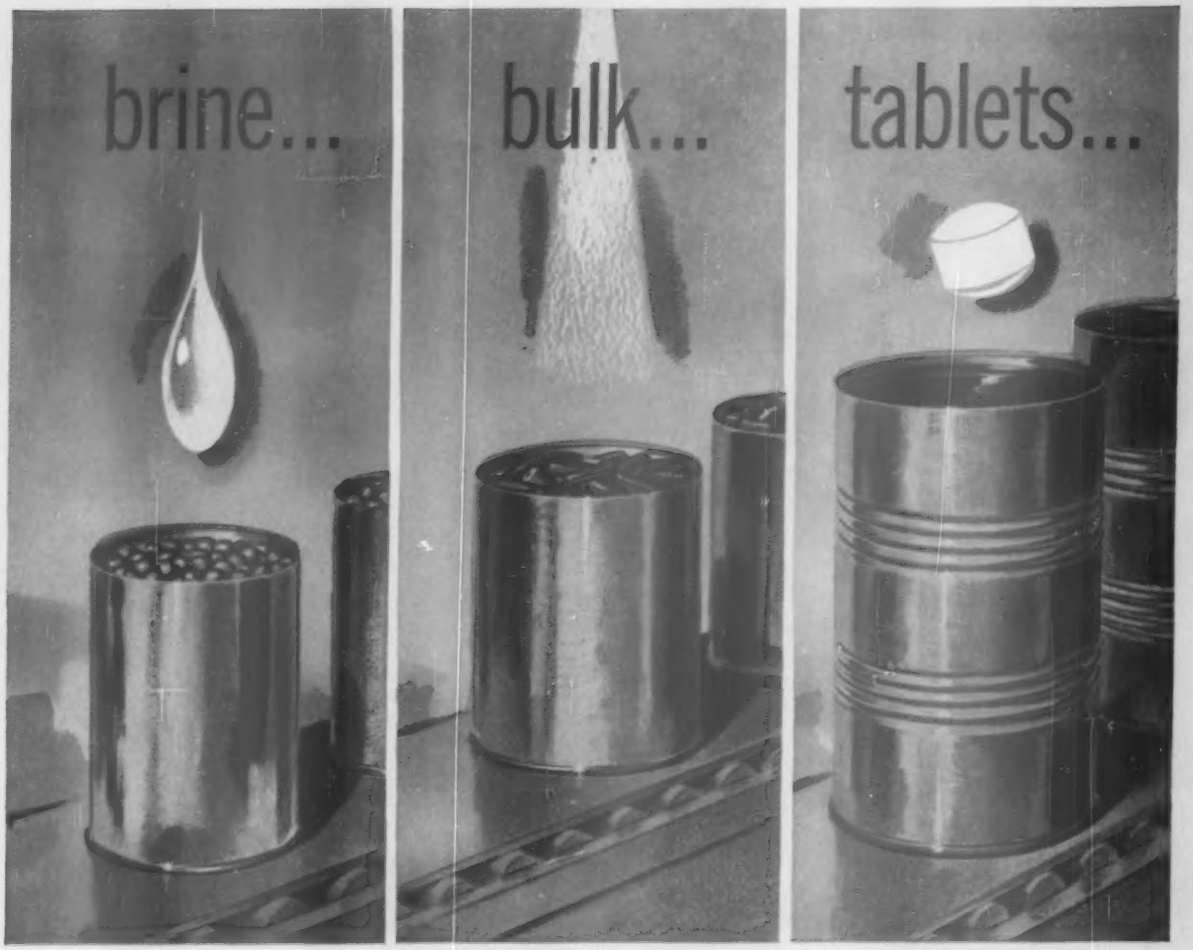

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(Continued from page 22)

of the problems encountered during World War II in feeding the troops. The main problem here was to produce a product the soldiers would eat. Other problems were stability of the product, convenience, ease of transportation, and safety.

He explained how the University of California developed its approach to these problems. The approach has men working in acceptance, flavor, color, stability, and the like. These men cooperate with technologists and engineers. To complete the "full spectrum" approach, representatives of such fields as horticulture and animal husbandry are also consulted. To make the program a success a close working relationship with industry is necessary.

In conclusion, Dr. Mrak stated that education in food technology and related sciences serves to interest men in the problems of the industry.

Al Rumminger then turned the gavel over to Seb Davin, our new chairman. Seb then gave Al an engraved gavel as a memento of his service to our section in the capacity of chairman for the 1956–57 year.

NEW YORK . . .

The final meeting of the 1956–57 season of the New York Chapter was held on Tuesday, May 7th, at the Brass Rail Restaurant. At this combined business-technical meeting, the following officers were elected for the coming season:

President—Dr. Harold A. Campbell (General Foods Corporation)
Vice-President—Dr. Kenneth Morgareidge (Food Research Laboratories)
Secretary—Mr. J. I. Lewis (Hoffman Beverages)
Treasurer—Dr. Richard R. Barton (Takamine Laboratories)
Regional Counselors—Dr. Ira D. Garard (Rutgers University), Mr. John Nair (Thomas J. Lipton Co.), Dr. Oscar Skovholt (Quality Bakers of America)
Directors—Mr. Alexander Astrack (Pak Research Associates), Miss Ruth Bien (Good Housekeeping Magazine)

Dr. J. C. Bauernfiend, the outgoing president, also announced honors to two other members of the New York Chapter. Dr. Axel Olsen (General Foods Central Laboratories) is the President-Elect of the IFT. Mr. Clinton Brooke (Merck & Co.) is the President-Elect of the American Association of Cereal Chemists.

In the final address of the current series based on the theme of new product development, Dr. James Allison, Professor of Biochemistry and Physiology at Rutgers University, speaking on "The Importance of Nutrition in New Product Development" observed that the public is "depending more and more on the food technologist to bring us our food and to apply our newer knowledge of nutrition to the new food products that are developed." He emphasized, however, that the public should strive for a balanced diet, not laying undue emphasis on fat, protein, carbohydrate, calories, or any other single component of the diet.

Dr. Allison's data showed how the biochemist and physiologist can control the diet to make laboratory animals fast growing, strong, and healthy, with excellent

(Continued on page 30 following technical papers)

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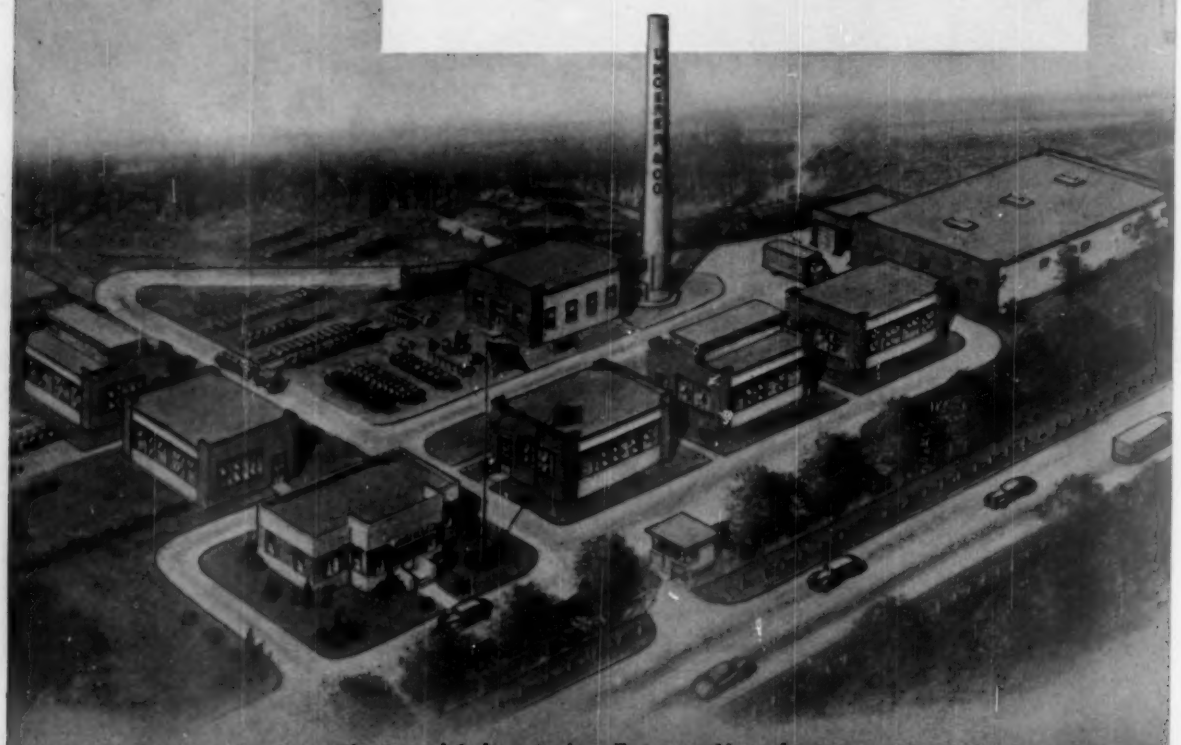

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Radiation Preservation of Cured Meats[a]

Anna Marie Erdman and Betty M. Watts
Department of Food and Nutrition, Florida State University, Tallahassee, Florida

(Manuscript received March 18, 1957)

ALTHOUGH A SUBSTANTIAL BODY of published information on radiation preservation of meats has become available within the past few years, a relatively small proportion of this is concerned with cured meats. A few exploratory studies have indicated that less objectionable off odors and flavors develop in pork during irradiation than in beef, lamb or veal *(10, 14)*. Bacon has been included in a list of foods showing little or no flavor damage even at sterilization doses *(14)*. Ham, bologna and frankfurters, on the other hand, have been reported to lose color and undergo flavor changes at doses approaching sterilization level *(9, 16, 17)*.

Recent studies on pigment changes in non-irradiated cured meats have demonstrated that oxidation (accelerated by light) of the ferrous heme pigment to the brown ferric compound may be inhibited if the meat contains free sulfhydryl groups or added ascorbic acid and nitrite. In the presence of such reducing compounds and nitrite, light faded pigments may also be restored to their original pink color *(21)*. On the other hand, the greening or greying of meat caused by porphyrin ring destruction is irreversible and seems to be associated with peroxide production, either of bacterial origin or as a result of unsaturated fat oxidation *(20)*.

Irradiation of fresh meat in the presence of oxygen results in discolorations which may be ascribed partly to the formation of ferric metmyoglobin and partly to porphyrin ring destruction resulting in the formation of a green compound *(7, 8)*. The discolorations are inhibited by the use of oxygen impermeable wrappings. The pigments resulting from irradiation of cured meats have not been identified.

Off odors which develop during irradiation of fresh meats have been attributed to volatile sulfur compounds resulting from the decomposition of glutathione and possibly of proteins containing sulfhydryl groups *(3, 13)*. Again, no similar studies on cured meats have been published. From a study of the previous literature it could be predicted that free sulfhydryl groups might protect cured meat color while at the same time contributing to off flavor during irradiation.

Ascorbic acid has been widely investigated for its protective effect on oxidative changes in non-irradiated *(4, 20)* and to a lesser extent in irradiated *(7, 10, 15, 16)* meats. Conflicting results have been obtained with its use in fresh meats, but both color and odor of irradiated cured meats may be improved by addition of this compound.

On the other hand, ascorbic acid may accelerate oxidation of animal fats in the presence of traces of copper. This prooxidant effect may be eliminated by combining ascorbic acid with certain commercial liquid smokes *(22)* and various copper complexing compounds *(11)*. There is not sufficient published information to know whether ascorbic acid, used to prevent color or flavor changes during irradiation, might accelerate fat oxidation during subsequent storage.

The present paper has as its objective the study of color and flavor changers in irradiated cured pork with special reference to the role of reducing compounds (sulfhydryl and ascorbic acid), nitrite, and liquid smoke. The investigation includes the irradiation of both commercially cured meats varying in nitrite and sulfhydryl content and also irradiation of fresh meats with and without curing ingredients.

METHODS

Radiation technique. A cobalt 60 (500 curies) radiation source was used for the major part of the work. The energy output over the period covered in this report was between 3.58 x 10^5 and 3.14 x 10^6 rep per hour. The size of the radiation source restricted the samples to a cylindrical space approximately 1½ x 4 inches. In order to obtain larger samples for analysis, one experiment was carried out in No. 2 cans irradiated at the Idaho Falls facility.

Packaging was not varied in any one experiment; however, several packaging materials have been employed during the course of the research. In the earlier work the samples were placed in glass vials or test tubes closed with paraffined stoppers. In one experiment Saran 75-gage double wound sausage casing from the Dow Chemical Company was used. This was discontinued because of the difficulty of obtaining an adequate seal. Polyethylene coated mylar *(23)* became available during the latter part of the study. This could be easily heat sealed and was suitable for the heat treatment of samples either before or after irradiation.

Sulfhydryl groups were determined with the nitroprusside test *(21)*. The test was carried out by placing on the meat surface a drop of concentrated ammonium hydroxide, followed by a drop of 5% nitroprusside. A deep rose color develops in the presence of free sulfhydryl groups. The color is stable for a few minutes. The intensity of the color was indicated roughly by + marks—i.e. +++ = bright rose, + = very slight test.

Nitrites were tested with a modification of a simple spot test *(6)*. Equal volumes of sulfanilic acid in acetic acid and alpha-naphthyl amine were mixed and a few drops of this mixture put on Whatman No. 54 filter paper. This was subsequently placed upon the meat surface. The intensity of the cherry red color that develops in the presence of nitrites was taken as an indication of the concentration. The application of the reagents directly upon the meat surface was found to be a less sensitive test. Moreover, the color intensity is difficult to evaluate on a pink meat surface.

Nitrites were quantitatively determined according to the A.O.A.C. official method *(1)*.

Rancidity was measured with the thiobarbituric acid method as described by Turner *et al. (18)*.

Meat color was visually evaluated. For cured meats one positive and two negative standards were used in the color comparison *(21)*. The positive standard consisted of a freshly exposed surface of the product under scrutiny. One negative standard, rated 0, consisted of a slice of the same product in which the pigment was oxidized to the ferric form by means of a treatment with potassium ferricyanide. The second negative standard, rated −10, was obtained by soaking a slice of the cured meat in a weak hydrogen peroxide solution, resulting

[a] This paper reports research undertaken in cooperation with the Quartermaster Food and Container Institute for the Armed Forces, and has been assigned number 733 in the series of papers approved for publication. The views or conclusions contained in this report are those of the authors. They are not to be construed as necessarily reflecting the views or indorsement of the Department of Defense.

in destruction of the porphyrin ring with resultant greenish-white color.

RESULTS AND DISCUSSION

Experiments on Commercially Cured Meats

Effect of irradiation on commercially cured meats. Two types of cured meat products were procured on the local market for this experiment. One was a canned ham which gave a strong test for free SH groups but contained no nitrite; the second was a bologna with no detectable SH groups but a high nitrite content.

Meats were sliced uniformly and the slices rolled and packed in test tubes which were sealed with a cork covered with paraffin. A strip of moist lead acetate indicator paper for the detection of hydrogen sulfide was inserted in each tube. Three irradiation dose levels were used: 2×10^5 rep, 6.7×10^5 rep and 2×10^6 rep. Controls consisted of unirradiated tubes kept at the same temperature as prevailed in the irradiation pit, i.e. 26° C. Immediately after irradiation and at the end of 3 storage periods (different for the 2 samples), at room temperature in the dark, a tube of each variable was examined for presence of nitrite, free SH groups, odor, color, and bacterial spoilage.

Time of appearance of gross signs of bacterial spoilage are given in Table 1. The lowest dose of 2×10^5 rep, arbitrarily chosen as being within the "pasteurization" range, did not delay the onset of bacterial spoilage in either sample. No further experiments have been performed at this low dosage. The intermediate dose (6.7×10^5 rep) prolonged the life of both samples but did not effect complete sterilization as evidenced by the sour odor of the ham at the longest storage interval of 44 days. In this and subsequent experiments, no bacterial spoilage was evident in samples radiated at 2×10^6 rep.

TABLE 1

Effect of irradiation dose on onset of bacterial spoilage in ham[1] and bologna[2]

Product	Dose (rep)	First appearance of	
		Sour odor (days)	H_2S (days)
Ham	0	3	3
	2×10^5	3	3
	6.7×10^5	44	>44
	2×10^6	>44	>44
Bologna	0	3	>3
	2×10^5	3	>3
	6.7×10^5	>29	>29
	2×10^6	>29	>29

[1] Nitroprusside test ++++; nitrite test —.
[2] Nitroprusside test —; nitrite test +++.

The lead acetate paper had been used with the idea that it might detect H_2S resulting from irradiation decomposition of sulfur containing compounds in the meat. However, in this and several other experiments, H_2S was detected only when other signs of bacterial spoilage were evident. Its use was later discontinued. Volatile sulfur compounds found in irradiated meats did not include H_2S *(13)*.

Definite off odors were detected in all irradiated samples, increasing in intensity with increasing radiation dose. The odors are difficult to describe and differed in quality for the 2 products used. In no case was the odor highly objectionable; however, it was not characteristic of the product. Prolonged storage did not change the odor of the ham. The bologna had a definite rancid odor after 7 days of storage.

The color of both ham and bologna faded markedly during irradiation, even at the lowest dose. The fading was irregular, but in wide areas the color approximated that of ferricyanide treated standards and appeared to be mainly ferric hemochromogen. Further irradiation up to 2×10^6 rep produced extreme spottiness. On the same piece of meat, some areas faded completely to that of hydrogen peroxide treated standards (porphyrin ring destruction) whereas smaller areas regained the original bright pink color. Upon subsequent storage all samples faded completely within a few days. It should be pointed out that these observations were on meat surfaces exposed to air. In later experiments in which solid plugs of ham, or tightly packed comminuted meats, were irradiated, the color was much less affected by the irradiation treatment.

Changes in nitrite and in surface SH groups are shown in Table 2. Free SH groups decreased both on irradiation and also on subsequent storage.

Meat which originally contained a relatively large amount of free nitrite (bologna) showed a significant decrease at doses of 6.7×10^5 and above. On the other hand, ham, which originally showed no free nitrite, gave a fairly strong test immediately after irradiation at all levels. The nitrite appearing during radiation is presumably produced by reduction of nitrate. Pure solutions of sodium nitrate gave strong tests for nitrite after radiation. A meat product containing nitrate but no nitrite, subjected to increasing doses, gave a positive test for nitrite after application of 2×10^5 rep. Barron *(2)* has pointed out that the products of the ionization of water by electromagnetic radiations could bring about either oxidation or reduction. Apparently both occur in meat.

Effect of surface application of nitrite on radia-

TABLE 2

Effect of irradiation on sulfhydryl and nitrite in ham[1] and bologna[2]

Product	Days after irradiation	Dose (rep)	SH	NO_2
Ham	0	0	++++	—
		2×10^5	++++	++
		6.7×10^5	++	++
		2×10^6	++	++
	6	6.7×10^5	++	++
		2×10^6	—	++
	44	6.7×10^5	—	—
		2×10^6	+	—
Bologna	0	0	—	++++
		2×10^5	—	++++
		6.7×10^5	—	++
		2×10^6	—	++
	7	6.7×10^5	—	—
		2×10^6	— ±	—
	29	6.7×10^5		—
		2×10^6	—	—

[1] Nitroprusside test ++++; nitrite test —.
[2] Nitroprusside test —; nitrite test +++.

tion damage. Previous work on light fading of cured meats *(21)* demonstrated that surface oxidation of the cured meat pigment could be inhibited by applying nitrite solutions to the surface, provided that reducing groups (either free SH groups from the meat protein or added ascorbic acid) were present. Concentrations of nitrite too low to prevent the light fading could bring about regeneration of the cured meat pigment on subsequent storage in the dark. Similar experiments were designed to determine what protection might be afforded by such treatments in meats subjected to ionizing radiations rather than visible light.

The 2 samples of meat used in Experiment I above, i.e. ham (originally high in SH groups) and bologna (no free SH) were radiated at 6.7 x 10^5 rep after dipping for 20 seconds in several concentrations of nitrite. The meats were prepared for radiation as in the previous experiment. After irradiation the meats were stored in the refrigerator (50° C.) in the dark and tested after eight days.

As might be expected, the bologna sample, lacking SH groups, was not benefited by nitrite dips. The application of a high concentration of nitrite (2%) to the ham surface prevented color loss during the radiation period. However, rapid loss of SH groups accompanied by fading of the color took place during the subsequent storage period. At the 0.2% level, nitrite did not prevent the radiation fading, nor was there any significant regeneration of color on subsequent storage.

Application of ascorbate and nitrite. The addition of sodium ascorbate (0.22%) alone and with 2 concentrations of nitrite was tried on a sample of bologna which originally gave a weak test for SH groups and a moderate nitrite test. Where both nitrite and ascorbate were used, they were combined in the same experimental dip, freshly prepared at the time of use. Dipping and radiation procedures were as in Experiment II.

Results of this experiment, compiled in Table 3, show a satisfactory protection was maintained during irradiation and a subsequent 8-day storage period, when 2% nitrite was combined with 0.22% sodium ascorbate. Odor evaluation of the products (complicated somewhat by the spice odor) indicated less irradiation off odor in the samples containing ascorbate. Odor ratings for the samples containing nitrite in combination with ascorbate were only slightly better than those for the samples with ascorbate alone.

While the addition of ascorbate with nitrite appears to have promise in protection against irradiation induced off odors and discolorations during short storage periods, there is a high probability that ascorbate will catalyze fat oxidations over longer storage periods. This occurred in experiments described below in which ascorbate was added to ground pork.

TABLE 3
Effect of pretreatment with nitrite and ascorbic on irradiated bologna

Treatment	Free SH		NO_2		Color rating	
	0 days	8 days	0 days	8 days	0 days	8 days
none	±	±	++	++	10	8
none, irr..	±	±	++	++	6	0
0.2% NO_2, irr.	±	±	++	++	5–6	2
2.0% NO_2, irr.	–	–	++++	++++	10	5
0.22% ascorbate	±	±	++	++	9–10	0
0.2% NO_2 0.22% ascorbate	±	±	++	++	7	4
2.0% NO_2 0.22% ascorbate	–	–	++++	++++	10	7

Irradiation of Ground Meat With and Without Various Curing Ingredients

In order to determine more precisely the effect of various curing ingredients and heat treatments on stablity of irradiated meats, a series of experiments was performed in which the starting material was raw ground meat, usually pork, rather than a commercially cured meat product.

Curing processes usually involve some heat treatment for the development of the cured meat color. However, it has been demonstrated that freezing raw pork containing curing salts, ascorbic acid and liquid smoke results in a cured product of good quality *(19)*. The cured meat color develops in a few days in the freezer since the ascorbic acid supplies the reducing action normally obtained from sulfhydryl groups freed during heating. The following experiments were patterned after this earlier work, but with the substitution of irradiation for freezing as a method for preserving the products.

Preliminary qualitative experiments on small lots. In several preliminary experiments raw meats were ground in the laboratory, given various experimental treatments, then packed as solidly as possible into small glass vials, leaving a head space of less than 1 cm. The vials were closed with paraffined corks and irradiated with 2 x 10^6 rep. Vials were opened immediately after irradiation and after storage periods of several weeks in the refrigerator. The meat was rated qualitatively for color, odor, and free SH groups.

Because of the small amount of samples available in these tests, the lack of quantitative data, and the limited storage periods, the results of these preliminary experiments are not reported in great detail. However, the following tentative observations were made.

Ground meats containing no curing ingredients. Irradiated raw beef had a stronger, more undesirable odor than irradiated raw pork. This has been pointed out by several previous workers *(10, 14)*. The off odors were not noticeably diminished after 12 days of storage.

Both pork and beef, when heated to a temperature of 70° C. were judged to have less off odor after irradiation than the corresponding raw meats. Whether the meat was heated before or after irradiation seemed to make no difference in the preference ratings.

All irradiated cooked meats had the pink color typical of cured meats rather than the characteristic gray or brown of ordinary cooked meats. Although no nitrite was used in these experiments, it is possible that nitrites or nitric oxides were produced by irradiation of air or of nitrogen containing compounds within the meat.

Ground meats containing curing ingredients. The effect of the addition of each of the following, separately and together, to comparable batches of raw ground pork

was noted: 2% NaCl, .06% $NaNO_2$, 0.11% sodium ascorbate and .05% liquid smoke. Addition of all these compounds together gave a product which was judged to be much better in color and odor after irradiation and subsequent storage for 50 days than the same meat irradiated with no additions or with the addition of any one of the above. The sodium ascorbate alone resulted in a rancid odor on storage which did not develop when the ascorbate was combined with liquid smoke. When liquid smoke was used alone or in combination, the intensity of the smoke odor was noticeably diminished during irradiation and was further decreased during the 50 day storage period.

With meats containing all the above ingredients, no clear cut conclusions could be drawn from tests made within brief storage periods as to whether it was better to irradiate and store the meat raw, to cook before irradiation, or to cook after irradiation. All of the cooked irradiated samples were judged better in odor than the raw. However, since the meat would normally be cooked before eating, it could presumably be irradiated and stored in the raw state if this proved feasible on longer storage periods. All samples, both cooked and uncooked, had a good pink color up to storage periods of several weeks in the refrigerator.

Storage studies on pork containing cure. To test the effect of the added cure with and without heat treatment over longer storage periods, larger samples were prepared for irradiation at Idaho Falls. For this experiment a fresh ham, frozen when purchased from a local meat packer, was deboned, ground in an electric meat grinder ($\frac{3}{16}$ inch plate), the meat thoroughly mixed and divided into 8 batches for experimental treatments.

Curing ingredients (2% NaCl, .06% $NaNO_2$, 0.11% sodium ascorbate and .05% liquid smoke) were added to all batches except one, which was held in the freezer without further treatment. The dry curing mixture was mixed thoroughly with each batch of meat. The meat was then weighed and shaped into uniform 70 g. patties and each patty was packaged separately in polyethylene coated mylar, which was heat sealed with a warm iron. Those which were to be cooked, either before or after irradiation, were immersed in boiling water for seven minutes. This heating period was predetermined to give an internal temperature of 70° C. within the patties.

For irradiation, several patties were sealed in No. 2 tin cans, which were held in a freezer at −17° C. overnight, then packed in dry ice and shipped to Materials Testing Ground at Idaho Falls. Non irradiated controls were prepared and shipped with the samples to be irradiated. All samples were thawed and irradiated at room temperature but repacked in dry ice for the return shipment.

Packages were opened for analysis 2, 60 and 170 days after their return. At each storage period samples were examined for evidence of bacterial spoilage, odor, and color and analyzed for nitrites, TBA and free SH groups. The unheated, unirradiated cured meat stored at room temperature showed bacterial souring at the end of 14 days: this and the preheated unirradiated samples were sour smelling at 60 days and badly spoiled (decomposed, heavy bacterial growth) after 170 days.

Results of the analytical tests are shown in Table 4. One hundred percent of the nitrite added was recovered upon immediate analysis by the method used. At the first storage period, this had been reduced to values ranging from 52% to 86%, with the greater losses in irradiated samples. Nitrite continued to decrease rapidly during storage. The amount remaining was negligible after 2 months.

Irradiation brought about an increase in free SH groups in the raw meat, but a decrease in the heated meat. This has been noted in several other experiments. The apparent increase in the raw meats may be attributed to partial protein denaturation resulting in a freeing of SH groups previously held in intramolecular linkages. In all cooked samples in which the meat protein is presumably fully denatured, free SH groups disappeared rapidly during storage and the nitroprusside test was completely negative at the end of 2 weeks.

TBA values increased only slightly over the storage period of approximately 6 months at room temperature. The maximum values were still within the range obtained on many fresh samples of meat by the method employed. The strong antioxidant properties of the ascorbic acid-smoke combination have been pointed out previously *(22)*.

As in the earlier experiments, all samples, irrespective of irradiation or heat treatment, had a good pink color characteristic of the kind of product, i.e. raw or cooked, up to 14 days of storage. At 60 days color differences were apparent which became very pronounced at 170 days.

Of the unheated samples, those which were not irradiated spoiled too quickly to use in organoleptic comparisons. The unheated, irradiated sample showed progressive browning and darkening. This discolora-

TABLE 4

Storage data on irradiated cured pork[1]

Code[2]	Heat treatment	$NaNO_2$ (% of original)			Free SH		TBA		
		2 days	14 days	60 days	2 days	14 days	2 days	60 days	170 days
C	Freezer control	68	63	54	+	+++	.083	.124	.098
N^1	Unheated	86	(—)[3]	(—)[3]	+	++	.090	(—)[3]	(—)[3]
I^1	Unheated	60	16	<2.0	++	++	.106	.134	.258
N^2	Preheated	78	22	<2.0	++	—	.085	(—)[3]	(—)[3]
I^2	Preheated	61	27	3.7	+	—	.111	.135	.183
N^3	Postheated	63	27	2.7	+++	—	.081	.088	.142
I^3	Postheated	52	19	6.2	++	—	.098	.102	.184

[1] Raw round pork containing 2% NaCl, .06% $NaNO_2$, .11% sodium ascorbate and .05% Firmenich liquid smoke.
[2] N = not irradiated, but shipped and stored at room temperature with irradiated samples; I = irradiated samples; C = meat containing curing ingredients stored immediately in freezer.
[3] Spoiled, not analyzed.

tion appeared to involve other changes than oxidation of the heme pigments. The color was much darker and browner than that obtained on complete conversion of the pigments to metmyglobin. The dark color and accompanying caramelized or malty odor suggested a browning reaction, probably accelerated by dehydroascorbic acid *(5, 12)*. Since this did not occur in any of the heated samples, it may be inferred that enzymatic activity within the raw meat accelerated the reaction, possibly by increasing free amino groups.

Little difference could be noted between pre- versus post-heated samples in color or odor within the first 2 weeks of storage. However, the preheated unirradiated sample spoiled, and the preheated irradiated sample lost all pink color (corresponded to hydrogen peroxide treated samples after 170 days), whereas the corresponding post-heated samples showed neither bacterial spoilage nor color loss at the longest storage period of 170 days. In fact, both of these samples were considered highly acceptable with a good cured meat odor at this time. It was difficult to distinguish between the irradiated and the non-irradiated samples and no consistent preference was shown for either one.

It is possible that the inhibition of color loss and bacterial spoilage noted in the post-heated samples may be related to enzymatic oxygen depletion in the sealed packages held in the raw state during the shipping and irradiation period, rather than to a particular sequence of the irradiation and heating operation. At least one of the chief oxygen depleting systems, i.e. succinoxidase, is still active in irradiated meats *(9)*. This point needs further investigation.

SUMMARY AND CONCLUSIONS

Commercial cured meats (ham and bologna) were radiated in air with gamma rays from a cobalt 60 source. Dosages ranging from 2×10^5 to 2×10^6 rep caused severe color losses, off odors, loss of free SH groups and marked changes in nitrite. The application of sodium ascorbate in the presence of excess nitrite gave color and odor protection during radiation and brief storage periods.

Ground pork mixed with curing salts, sodium ascorbate and liquid smoke, radiated and subsequently heated to destroy enzymes, retained good color and odor over a storage period of 6 months at room temperature. Free nitrite and SH groups disappeared during storage. Similar samples radiated but not heated underwent a browning reaction during storage. Samples heated immediately after packaging (before radiation) lost color during storage, possibly because of less opportunity for enzymatic exhaustion of oxygen within the meat tissues.

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The Effect of Alternate Freezing and Thawing on the Total Flora of Frozen Chicken Pies[a]

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THE RAPID DEVELOPMENT of the commercial frozen meat and chicken pie industry has raised many problems of handling. A particular problem is the control of the total bacterial flora at a level which will at least partially insure a considerable margin of safety against spoilage. Total counts may not serve, however, as an index to quality since many factors may influence the number and type of organisms present. These studies were primarily designed to determine the effect of various holding temperatures and alternate freezing and thawing on the total flora of coommercial frozen chicken pies. Earlier it has been shown *(1)*, 1957, that alternate freezing and thawing does not increase the total count in commercial frozen vegetables providing growth is not initiated in the thawing phase.

Data. A total of 3,372 observations were made on 443 samples of commercially frozen chicken pies obtained from six different processors. Ten gram samples were disintegrated in a sterile Waring blender with 90 cc. of water. In most instances the samples were taken from the center of the pies. In those instances in which the effect of different holding temperatures on the same pie was concerned, the pies were cut in equal sections and each treated as an original pie sample. Tryptone-glucose-yeast extract agar was used in the plating medium and plates were incubated as follows: 0° C. (32° F.) for 28 days, 20° C. (68° F.) for 5 days, and 32° C. (89.6° F.) and 45° C. (113° F.) for 2 days.

TOTAL COUNT AND COLIFORMS IN FROZEN CHICKEN PIES

A detailed study of 52 frozen chicken pies from two processors showed a rather uniform total count. One processor's (A) samples indicated more uniform counts with a lower average than from a second processor. The second processor's samples (B) although showing a higher average count, appeared to be divided into groups, one showing a high, the other only a small number of organisms. These results indicate a variation in operating practice or a build-up of resistant organisms in the equipment.

Five-gram samples of each disintegrated frozen pie was inoculated into lactose broth. Forty-five percent of the samples produced gas, all of which confirmed as positive for *Escherichia coli*. It may be of some interest that only 33% of the chicken pies with the higher average count from one processor showed gas while 51% from the processor with the lower counts showed gas in lactose broth.

Of the one hundred and thirteen strains isolated from the frozen pies, 38 were micrococci, 21 were spore-bearing rods, 30 Gram negative rods and 24 were the large biscuit shaped types. The systematic relationships of these biscuit shaped strains is not clear although they commonly are encountered in many frozen products. They may be variants of known species of micrococci or they may constitute a hitherto unknown and yet to be described genus.

The dark and white meat as well as the thickened broth were examined separately in a series of 12 frozen pies. Little difference in total count was noted as between the light and dark meats but the broth in many instances showed a considerably lower total count.

EFFECT OF HOLDING AT 2° C. (35.6° F.) and 7° C. (44.6° F.) ON THE TOTAL FLORA OF COMMERCIAL FROZEN CHICKEN PIES

Three hundred and ninety-one samples of frozen chicken pies were equally divided and one-half held at 2° C. (35.6° F.) and the other at 7° C. (44.6° F.). These temperatures were selected as approximating the minimum temperature at which the frozen pies would remain thawed, 2° C. (35.6° F.), and the temperature of the average domestic refrigerator 7° C. (44.6° F.). The thawed pies were held at these temperatures for 48 hours and examined at regular intervals. A remarkable uniformity of results was found in all samples. The counts obtained from pies from one processor, Figure 1, were somewhat lower, on the average, than the counts obtained from the pies from the second processor, Figure 2.

The mesophilic counts, 21° C. (69.8° F.) and 32° C. (89.6° F.) were similar in all samples. The thermophilic counts, as shown by number of colonies on

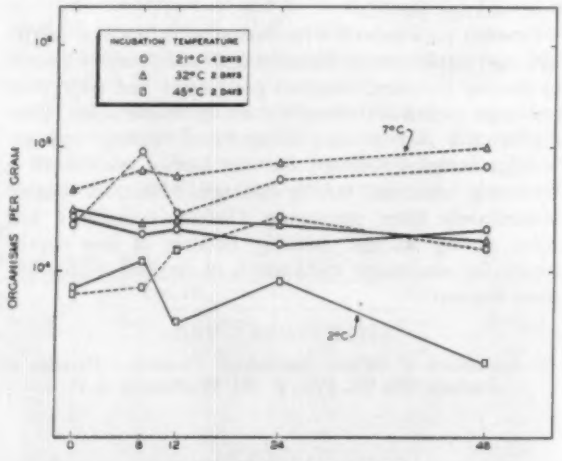

Figure 1. Growth in thawing commercial frozen chicken pies (processor A) when held at 2° C. and 7° C.

[a] Journal Paper No. 1064, New York State Agricultural Experiment Station, Cornell University, February 1957.

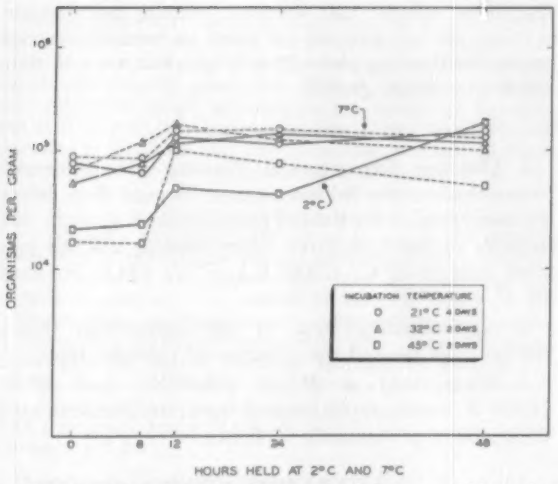

Figure 2. Growth in thawing commercial frozen chicken pies (processor B) when held at 2° C. and 7° C.

45° C. (113° F.) plates was lower than the mesophilic counts as shown by the number of colonies appearing on the plates incubated at 21° C. (69.8° F.) and 32° C. (89.6° F.). Only a small number of psychrophilic types, as shown by growth at 0° C. (32° F.) were observed in any of the samples.

Little change in the total flora of frozen chicken pies, Figures 1 and 2, were found when the samples were held at 2° C. (35.6° F.) and 7° C. (44.6° F.) for 48 hours. Minor changes were observed after 8 to 10 hours holding.

RELATION OF MAXIMUM TIME AND TEMPERATURE OF HOLDING TO INITIATION OF GROWTH IN THAWING CHICKEN PIES

A series of 70 samples of commercial frozen chicken pies were held at a range of temperatures from 2° C. (35.6° F.) to 32° C. (89.6° F.). Samples were placed at various time intervals using 32° C. (89.6° F.) as the incubation temperature. It may be noted, Figure 3, that pies held at 2° C. (35.6° F.) did not show an increase in total flora at the end of 70 hours. At the end of 40 hours the organisms in pies held at 7° C. (44.6° F.) had not initiated growth. At the higher temperatures, however, particularly at 21° C. (69.8° F.) or above, from 8 to 10 hours was the minimum holding time possible before appreciable growth was evident.

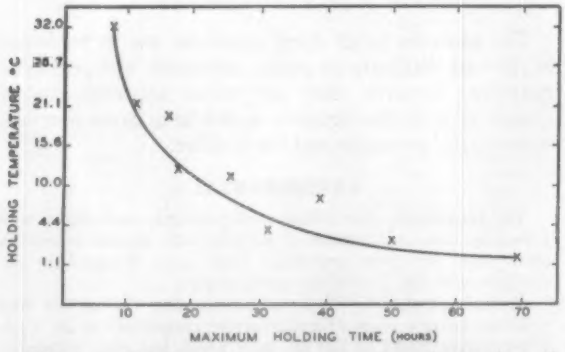

Figure 3. Relation of temperature and maximum time of holding to initiation of growth in thawing commercial frozen chicken pies.

EFFECT OF ALTERNATE FREEZING AND THAWING ON THE TOTAL FLORA OF COMMERCIAL FROZEN CHICKEN PIES

Five series of commercial frozen chicken pie samples were passed through 4 alternate freezing and thawing cycles. Samples were held for 8 hours with the temperature of the respective thawing phases of 2° C. (35.6° F.) 7°C. (44.6° F.), 18° C. (64.4° F.), 21° C. (68.8° F.) and 32° C. (89.6° F.). A duplicate series was observed in which the holding time for the thawing phase was increased to 12 hours.

Again, almost complete conformity to one pattern of results was observed as indicated by a representative series, Figures 4 and 5. In those cases in which the thawing phase was limited to 8 hours, Figure 4, no

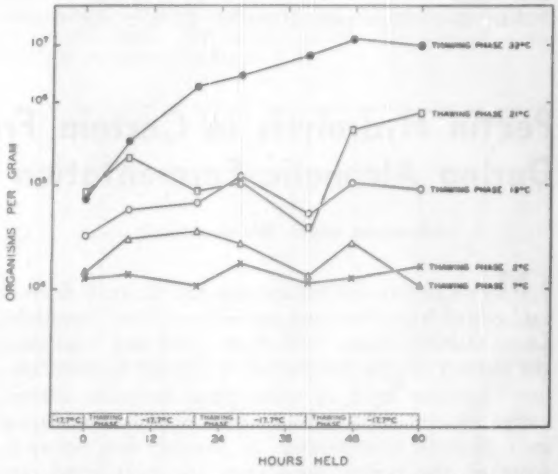

Figure 4. Effect of alternate freezing and thawing on total flora of commercial frozen chicken pies when thawing phase is eight hours.

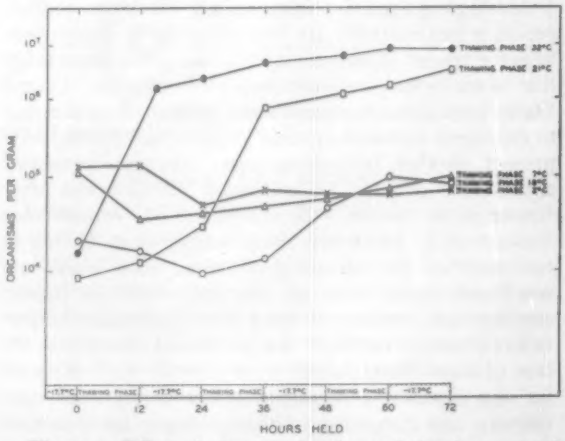

Figure 5. Effect of alternate freezing and thawing on total flora of commercial frozen chicken pies when thawing phase is twelve hours.

appreciable increase in the total flora was noted if the temperature of this phase was held at 18° C. (64.4° F.) or less. Even with 21° C. (69.8° F.) as the thawing temperature an appreciable increase in count did not occur until the third freezing and thawing cycle. In the series in which the thawing temperature was 32° C. (89.6° F.) a rapid and gradual increase in flora was found through each succeeding cycle of freezing and thawing.

An increase of the thawing cycle to 12 hours resulted in a more rapid increase in count, Figure 5, during the freezing and thawing cycles than when 21° C. (69.8° F.) and 32° C. (89.6° F.) were employed as the thawing temperatures. In those cases in which the thawing temperature was 18° C. (64.4° F.) or lower, an appreciable increase in count was noted when the chicken pies were passed through 3 freezing and thawing cycles.

It may be noted, Figure 3, that approximately 8 hours is the maximum time of holding at 32° C. (89.6° F.) before growth is initiated while a little longer is required at a temperature of 21° C. (89.6° F.). These results, similar to those reported earlier (1957) for frozen vegetables, indicate that alternate freezing and thawing of frozen chicken pies will not affect an increase in count unless the thawing phase is at a temperature and time which will initiate growth.

CONCLUSIONS

1. Alternate freezing and thawing of commercial frozen chicken pies did not increase the total flora unless the conditions of the thawed phase initiated growth. No increase in count occurred when thawing chicken pies were held at 2° C. (35.6° F.), 7° C. (44.6° F.) and 18° C. (64.8° F.) for 48 hours.

2. Approxmately 50% of the commercial frozen chicken pies showed the presence of coliform types.

3. When held at 21° C. (69.8° F.) and 32° C. (89.6° F.) chicken pies showed the first increase in total flora after approximately 10 hours.

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Pectin Hydrolysis in Certain Fruits During Alcoholic Fermentation

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(Manuscript received February 5, 1957)

Many fruits are fermented into alcoholic drinks: e.g., grapes into wines and apples into cider. Similarly, many cannery wastes from both fruits and vegetables are utilized for the production of ethanol by fermentation. Because most of these plant materials contain varied amounts of pectin, it often happens that during their alcoholic fermentation, or probably just before it, some of the pectin substances are hydrolyzed, the methoxyl groups split off, and the resulting drink then contains greater or lesser amounts of methanol alongside with ethanol.

Although grapes, for instance, are known to contain pectin, wines normally are free of methanol except perhaps for traces. However, it has come to our knowledge that some wines recently imported into the United States from other countries were refused admission due to excessive methanol content. Apples and citrus fruits present another interesting case: whereas fermented apple cider contains no methanol, citrus juices after fermentation exhibit the presence of considerable amounts of it. Moreover, citrus wastes when serving as raw material for ethanol production, both limed and non-limed, result in spirits practically unfit for human consumption because of their high methanol content, unless properly rectified. An additional example is the case of sugar beets, which were recently used in Israel for the production of ethyl alcohol before the sugar refinery was completed. Although sugar beets contain comparatively large quantities of pectin, most distilleries received nothing but traces of methanol in their final product while others got a considerable amount of it.

On the strength of these and similar examples the writers thought it proper to make a preliminary survey of the entire field in order to elucidate the following points:

(a) Can the pectin be demethoxylated by yeast fermentation alone?
(b) Why do two plant materials containing equally large quantities of pectin differ so utterly in their methanol content after fermentation?
(c) What is the reason for the wide differences in methanol content after fermenting one and the same plant material when treated under different conditions of pH and temperature?

The answers to all three questions are to be found in the vast literature on pectic substances and pectolytic enzymes; however, they are rather scattered, and a clearer view on the situation would be of great practical value to the processor and the distiller.

EXPERIMENTAL

The experiments that follow were primarily undertaken with a view to seek confirmation of various facts already known on pectin and pectolytic enzymes. They were designed in accordance with the 3 questions posed above.

Methods employed. All fermentations were carried out with ordinary baker's yeast *(Saccharomyces cerevisiae)* at 30° C. in Ehrlenmayer flasks of 500 ml. each which had been previously sterilized with the media at a steam pressure of 15 lbs. p.s.i. for 25 min.

Measurements of ethanol were made by means of a densimeter after distilling 100 ml. of the fermented media. Estimates of methanol were made by the Klett-Summerson Photoelectric Colorimeter using the green filter (5000 Å) which exhibits the most convenient range, according to the method of Denigès, described by A.O.A.C. *(6)*, the solutions having been prepared according to Woodman *(7)*. For comparison, standard solutions were prepared containing pure methanol dissolved in 5% ethanol-water in various proportions. Readings on the arbitrary scale of the Klett photocolorimeter were plotted against these standards and being proportional to the optical density it was easy to establish the relation between the scale reading, the percentage of light transmission, and the percentage of methanol in solution.

Measurements of pectin esterase (PE) activity were made by means of a Beckman Potentiometer with a glass electrode according to the method originally developed by Kertesz *(3)* and subsequently modified by others *(5)* in which the increase of free carboxyl groups was determined by the amount of 0.1 N NaOH consumed during 30 min., in order to keep a given pectin solution at pH 7.

A. Experiments in model solutions

The question whether yeasts alone can cause the demethoxylation of pectin was tested on a series of model solutions all containing 10% sucrose, some ammonium phosphate (1% of the sucrose) and various amounts of pectin. All samples were brought to pH 3.5 by means of citric acid, sterilized as above, and baker's yeasts were added after cooling. In all, two series of 4 experiments each were run, every experiment comprising three equally set up test flasks. The results are presented in Table 1—experiments 1 to 8.

When all the above experiments showed negative results, further series of the same tests were run with the addition of fungi such as *Aspergillus niger* (experiments 9 to 13 in the above table) and *Penicillium glaucum*. The fungi were left to act on the pectin solutions for 3 days at the end of which the whole was sterilized, innoculated with baker's yeast and methanol contents estimated after the fermentation. (See Table 1, experiments 14 to 18).

B. Experiments with yeast juice

A series of experiments was then run with triturated yeast cells in a solution containing 10% sucrose, 0.5% pectin at pH 4.5. The yeast cells were triturated by known methods in a Fisher disintegrator using (a) carborundum (SiC), (b) silicic acid (SiO_2) and (c) corrundum (Al_2O_3). A microscopic examination after trituration showed that 78–80% of the yeast cells were completely broken. To these three runs a blank was added using untriturated yeast for control.

TABLE 1

Test No.[1]	Pectin content % of T.S.S.	Action of fungi, hrs.	Fermentation time, hrs.	pH	% Methanol	% Ethanol
1	none		72		none	4%
2	0.25		72		none	4%
3	0.50		72		none	4%
4	0.70		72		none	4%
5	none		96		none	4.5
6	2.5		96		none	4.5
7	5.0		96		none	4.5
8	7.5		96		none	4.5
9[2]	none	72	120		none	none
10	0.50	72	120		>0.1	none
11	1.25	72	120		0.1 to 0.2	none
12	2.50	72	120		0.3 to 0.4	none
13	5.0	72	120		well over 0.5	none
14	5.0	72	96	0.6	none	no fermentation
15	5.0	72	96	2.2	>0.1	4%
16	5.0	72	96	6.0	over 0.5	4%
17	5.0	72	96	12.0	over 0.5	no fermentation
18	5.0	72	96	13.0	over 0.5	no fermentation

[1] Each test comprised 3 parallel runs.
[2] Each of the following tests comprised in addition a blank containing no fungi for control.

All solutions equally fermented to the end and at the same rate. After fermentation they were distilled and the distillate showed a negative reaction for methanol.

C. Experiments with different pectin containing plant materials

Following the experiments in model solutions, a series of tests were set up with the following pectin-containing fruits and vegetables: apples, beets, sugar beets, oranges, lemons, grapefruit, guavas and tomatoes. In each case, the material was disintegrated in a Waring blender and brought up to a slurry in which the solution showed approximately 10° Brix. Baker's yeast was then added and the whole was set at different pH, namely 3, 5, 6 and 7. Fermentation was in all cases terminated after 72 hours and the ethanol contents varied between 4% and 5% by volume. Only citrus fruits (oranges, lemons and grapefruit) and tomatoes exhibited the presence of methanol (<0.1%).

When tested for the presence of PE by the method of Kertesz *(4)*, again only citrus fruits and tomatoes gave a positive reaction for this enzyme.

D. Influence of pH

On one and the same plant material the influence of pH was tested on citrus peels with a high content of PE. These were disintegrated as before and fermented with baker's yeast at various pH levels. The amounts of methanol received in the distillates are shown in Figure 1.

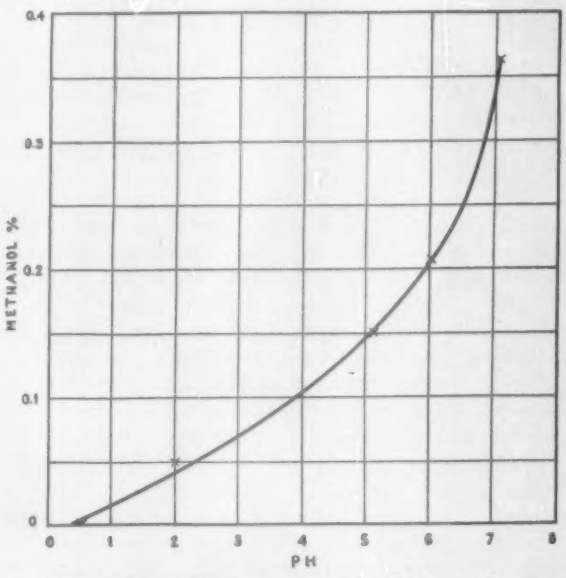

Figure 1. PE activity in citrus peel juice (measured as percent of methanol) at different pH.

RESULTS AND DISCUSSION

Results in Table 1 clearly show that model solutions of sucrose containing various quantities of pectin had no methanol after fermentation. Indeed, if the yeasts themselves would not split the methoxyl groups there would hardly be any other cause to account for, because any amount of PE possibly present in the model solution, would have been inactivated by sterilization.

On the other hand, the introduction of fungi, such as *Aspergilli* or *Penicillia*, quickly changed the picture: after a comparatively short time the pectin present was demethoxylated by the fungi. This probably also explains why wines may often contain some methanol

after fermentation; if the grapes carried with them some fungi, the latter's PE contents would be sufficient to hydrolyze the pectin.

Because of the failure of the yeasts to exhibit the action of PE it was thought that the many hydrolytic enzymes present in yeast are all intracellular components *(2)*, whereas the fungi work apparently extracellularly. This point was worth further elucidation. It may well be that if the hydrolytic enzymes of yeast are present intracellularly, they could not attack the pectin molecule which is quite large and cannot penetrate the semipermeable yeast membrane. The above reasoning called for a fermentation experiment in which yeast juice could be used instead of intact yeast cells, thus enabling the intracellular hydrolytic enzymes, if present, to act on the pectin molecule.

However, as mentioned above, the experiments with yeast juice gave also negative results. Thus, the baker's yeast used by us contained virtually no PE, not even intracellularly. This confirms previous observations by Kertesz and others *(5)* who were unable to show the presence of PE in *Saccharomyces cerevisiae*.

Turning from model solutions to fresh fruits and vegetables, it was found, as expected, that only citrus fruits and tomatoes, which actually exhibited the presence of PE gave place to pectin hydrolysis. It is obvious, then, that at acid or neutral pH and at normal temperatures, only pectin-containing materials which have also at the same time the PE can give rise to methanol on fermentation. No methanol will appear in the absence of the enzyme.

When investigating specifically the influence of pH on the same plant material, it was observed that in the range of pH up to 2, there were no appreciable amounts of methanol (0 to less than 0.1%). From pH 2.0 up to pH 7.0 the content of methanol rises quickly with the rise of pH. These findings are in agreement with the general statement by Kertesz *(4)* summarising different opinions on this matter. At higher pH ranges the PE activity is said to be even stronger. However, it is obvious that in such cases the demethoxylation can be related rather to the action of the alkali than to PE alone.

As far as thermal influence is concerned, we could only say that in the experiments carried out by us, no demethoxylation occurred while heating pectin solutions at 100° C., 110° and 115° C. for time periods of up to 2 hours, but on further elevation of the temperature to 120° C. traces of methanol were detected. These experiments were performed in three media: (a) models of sugar and pectin, (b), apple pulp and (c) sugar beets.

However, the alcohol produced from sugar beets by one plant in Israel contains very considerable amounts of methanol. This plant disintegrates the beets by the Henze process, which consists of cooking them in an autoclave at a pressure of 4 atm. followed by a quick release of the pressure. The demethoxylation of the pectin in this case can only be explained by the treatment at this high temperature. Further experiments in this direction are now in progress.

SUMMARY

A preliminary survey was made in order to elucidate several points regarding pectin hydrolysis in certain fruits during alcoholic fermentation.

Apparently pectin is not hydrolyzed by ordinary baker's yeast during fermentation, nor does it become hydrolyzed with yeast juice.

Unless the fruit in question contains pectin esterase, or the medium is contaminated by fungi, which in most cases contain this enzyme, the pectin is not hydrolyzed during fermentation and no methanol is formed.

Differences in preparation procedures before fermentation, such as liming and thermal treatment are largely responsible for the wide differences in methanol content of alcohol produced from one and the same plant material.

The influence of pH on the PE activity of citrus peel juice was explored.

Acknowledgment

The authors wish to express their appreciation to Professor M. Ashner and to Dr. Gideon Zimmerman of this Division for their valuable advice and interest in this work.

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Effect of Low Moisture Levels on the Thermostability of Active Dry Yeast[a]

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(Manuscript received March 27, 1957)

COMMERCIAL ACTIVE DRY YEAST (ADY) contains about 8.0% moisture and is considered to have satisfactory stability qualities for most civilian uses. However, owing to the special conditions likely to be met in the handling and storage of food supplies for the Armed Forces, it has been considered highly desirable to have an active dry yeast of improved stability for military uses.

This opinion was strengthened by the study of Felsher, Koch and Larsen *(2)* who found that the commercial ADY types available for military procurement were increasingly sensitive to temperatures above 70° F., even though packed in cans under nitrogen or vacuum. Although the yeast stored at 70° F. made acceptable bread after 21 months but not after 24 months, this desirable stability behavior was reduced to between 6 and 9 months for the yeast samples stored at 90° F. When the yeast was stored at 120° F. for 8 days, it produced bread of minimum quality, and after 12 days' storage the loaves were completely unacceptable.

In addition to the damaging effect of high temperature, it has been well recognized for some time through studies like those of Crane, Steele, and Redfern *(1)* and Morse and Fellers *(4)* that moisture contents of ADY above 8.3% significantly shorten the shelf life of this product. As to the effects of moisture levels below 8.0%, there has been very little published. It appears to have been the experience of active dry yeast producers that when the yeast is dried to moisture lower than 7.5% the product performs at a greatly reduced efficiency as a leavening agent.

This confirms the teachings of Ohlhaver *(5, 6)* who found, by and large, that the drier the yeast, the more it lost its leavening power. However, he also learned that by subjecting thin layers of the low moisture yeast to a humid atmosphere, the yeast was activated so that it could be dispersed in water for its customary handling in the preparation of good doughs and bread.

Ohlhaver *(6)* also appears to be the first investigator who used in-package desiccation in connection with active dry yeast. He observed that this method made it possible to keep yeast at 104–113° F. for 7½ months without adverse effect on performance. The same dry yeast in airtight containers, but without the addition of the separately inclosed hygroscopic substance, lost about 70% of its activity in 2 weeks at the same temperature.

Since active dry yeast is uniquely different from most other food products in that it is made up of viable cells capable of respiration *(1)*, it appeared desirable to investigate whether the observed beneficial effects of low moisture levels on the stability of food products such as milk, egg, tomato juice, and orange juice would also hold true for yeast.

Ohlhaver *(5, 6)* left many questions to be answered in the light of present knowledge. Among the more important points that have been studied on a laboratory scale are the following:

(1) the practical methods of reaching the lower moisture levels, and
(2) thermostability as a function of moisture levels below 8.0%.

EXPERIMENTAL

Drying methods. The first processing treatments to reach low moisture levels were carried out in vacuo as follows: 300 g. of a good quality granulated commercial ADY of 7.5% moisture were placed in a 5-liter round-bottom flask and subjected to a reduced pressure of 5 to 40 μ for different periods at a temperature of 80° F. Moisture determinations done at successive periods for 48 hours gave the drying curve shown in Figure 1.

As would be expected, Figure 1 shows a decreasing rate of water removal as the yeast becomes drier. At the end of the first 12 hours, the yeast had a moisture level of about 4.0% and after 24 hours had a moisture content of about 3.0%. During the next 24 hours, the moisture level dropped only 0.2%, from 3.0% to 2.8%.

Standard baking tests on low level moisture yeast samples resulting from vacuum drying showed that yeast of 5.5% was satisfactory for bread making after 50 days' storage at 115° F. if the samples were allowed to stand in a fermentation cabinet at 86° F. and about 90% relative humidity until the moisture content reached about 8.0%. Also, when similarly treated, the yeast of about 4.0% moisture was satisfactory after 80 days' storage at 115° F., while the control yeast of 7.5% moisture was acceptable for only 10 days under the same storage conditions. All yeast samples were packaged in 200 x 300 cans under 29-inch vacuum.

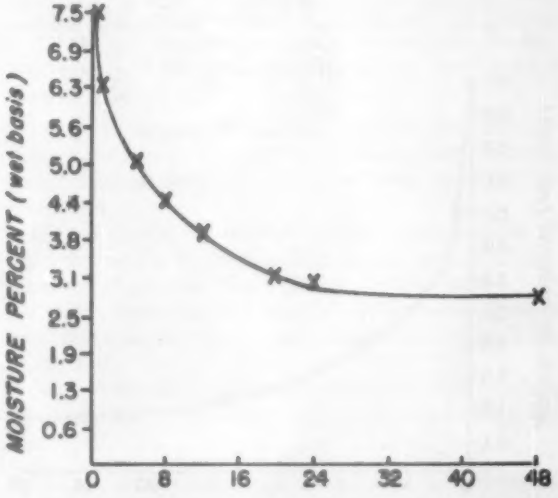

Figure 1. Moisture levels during vacuum drying.

[a] Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 14, 1957.

It should be emphasized that these low moisture yeasts made very poor bread, even immediately after drying, if they were directly dispersed, as is usual, in water at 110° F. without the preliminary vapor-treatment of 1 or more hours to bring them back to a 8–10% moisture level.

In addition to vacuum drying to process the yeast to lower moisture levels, preliminary experimentation was conducted using a circulatory-air drier and also in-package desiccation. The fluidized bed drier was able to reduce the moisture content of yeast to a 5.0% level in an ordinary day's run of 7 hours. In order to study the amount of thermostability at several moisture levels down to the bone-dry state, the desirability of using in-package desiccation was also explored. This latter method proved to be both a convenient and probably an economical method of producing yeasts of different lower moisture levels. It was found that heat-sealed envelopes of soft kraft crepe paper (trade name Promset) containing 4, 7, 10 and 20 g. of anhydrous CaO placed in 200 x 300 cans vacuum packed with 50 g. of regular commercial ADY would reduce yeast samples to the following moisture levels, respectively: 5.5, 4.0, 2.2% and 0.0%. The control samples of 7.5% were packaged in the same manner without desiccant.

All the cans of yeast were stored in a room of 73° F. to come to moisture equilibrium before being subjected to stability studies at 115° F. The two smaller quantities of 4.0 and 7.0 g. of CaO effected an equilibrium moisture condition within one week, but 27 days were required for the ADY in the cans containing 10 g. of CaO to reach the level of 2.2% moisture. The series of cans holding the excess of desiccant to bring about the bone-dry condition had reached 0.3% moisture at the 43rd day moisture determinations. The stability studies at 115° F. were started at this time and after 1 and 2 weeks' storage the latter yeast samples showed 0.04% and 0.0%, respectively.

In one of the exploratory tests an excess of CaO was used in a number of cans of yeast, and the drying curve noted in Figure 2 was obtained.

It is seen in Figure 2 that a moisture level of 2.5% was reached within a week by using the CaO desiccant. As will be observed from the thermostability studies in a later graph, the baking results indicate that it will be undesirable to produce yeasts much below this level. Although Figure 2 shows the drying curve in this particular experiment for 28 days when the yeast had reached a moisture of 1.2%, it will be remembered that in our main production of canned samples for storage studies, 43 days, under the same conditions, were required to reach 0.3%.

Stability studies. The main objective of this study was to determine storage life of ADY of different moisture levels at 115° F. as compared to that of commercial ADY of about 8.0%. At successive weekly periods cans of yeast having moisture contents of 7.8, 5.5, 4.0, 2.2, and 0.0%, were subjected to the Standard Bake Test after preliminary moisture-vapor treatment to return the samples to 8.0–10.0% moisture.

During this storage study the vapor treatment was conducted as follows: 20 g. of the yeast batches were placed in a 3-inch petri dish in layers of ⅛ inch depth and set in the fermentation cabinet the day before the bake tests. Conditions in the cabinet were 86° F. and about 90% relative humidity. Table 1 shows the increase in moisture content of yeast with time.

TABLE 1

Increase in moisture content of ADY during vapor rehydration

Hours in fermentation cabinet at 86° F.– 90% R.H.	Moisture content (Wet basis) %
0	3.5
1	6.3
2	8.7
3.5	10.5
4	12.2

When the samples had reached 8.0–9.0% moisture, the samples were stored in small air-tight jars overnight. The next morning the yeasts were subjected to hte Standard Army Bake Test, taking care to use an equivalent amount of yeast dry solids in all tests.

The bake test with one modification was the same as used in the previous stability tests of commercial ADY *(2)*. Since water of 110° F. was used to disperse the yeast, it was not necessary to use a preliminary revivication step in sugar solution *(3)*. As in the former study, special emphasis was placed on loaf volumes as an index of bread quality produced by the stored samples of yeast. Generally, as the loaf volume decreased there was a corresponding reduction in other desirable qualities of the dough and bread. Loaf volumes have the meanings as shown in Table 2. These interpretations have been developed through much experience with this test at the Quartermaster Food and Container Institute for the Armed Forces.

TABLE 2

Interpretation of loaf volumes

2200 cc. ± 50 cc. = Unacceptable Bread
2300 cc. ± 50 cc. = Fair Bread
2400 cc. ± 50 cc. = Good Bread
2500 cc. ± 50 cc.= Very Good Bread
2600 cc. and above = Excellent Bread

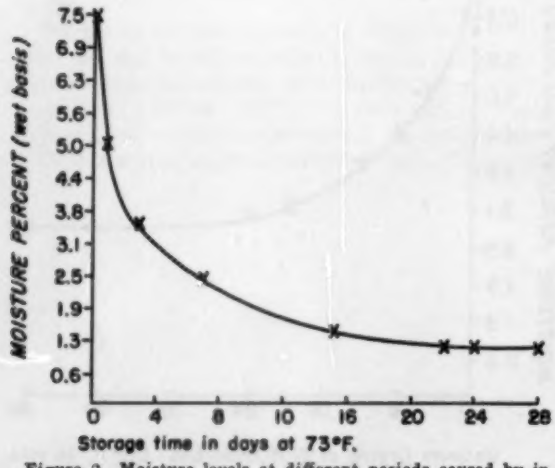

Figure 2. Moisture levels at different periods caused by in-package desiccation with CaO.

RESULTS AND DISCUSSION

The main results of this investigation are given in Figure 3. It is seen in this figure that the control yeast of 7.8% moisture gave a loaf volume of 2650 cc. before storage. Before storage, the yeasts of 5.5, 4.0, and 2.2% gave greater loaf volumes, from 2850 to 3000 cc., a confirmation of an observation made by Ohlhaver *(5, 6)*. On the other hand, the almost bone-dry yeast, even with the preliminary vapor-treatment, produced a loaf of 2350 cc. volume and gave barely acceptable bread for 4 weeks during storage at 115° F. After this period, this bone-dry yeast gave bread of very inferior quality.

With respect to other low level moisture yeasts after storage at 115° F. Figure 3 shows that the ADY samples of 5.5, 4.0, and 2.2% moistures made satisfactory bread for 6, 12, and 24 weeks, respectively. On the other hand, the control yeast of 7.8% moisture made satisfactory bread after 1 week's storage at 115° F., but not after 2 weeks. In the interpretation of the plotted curves in Figure 3, it appears that yeasts of 7.8, 5.5, 4.0 and 2.2% make acceptable bread for 10, and at least 40, 80, and 170 days, respectively.

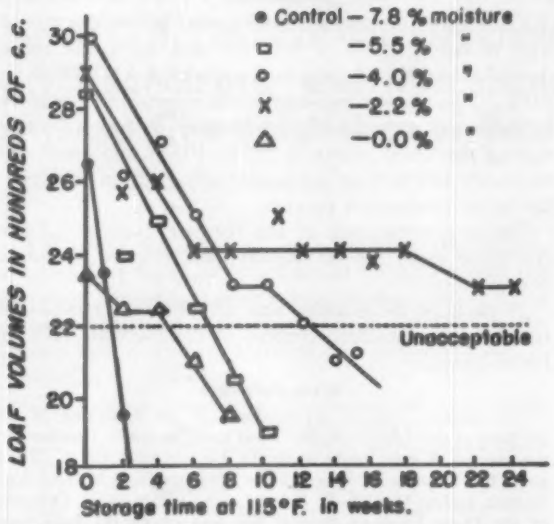

Figure 3. Loaf volumes of bread made with yeasts of different moisture levels after different storage periods at 115° F.

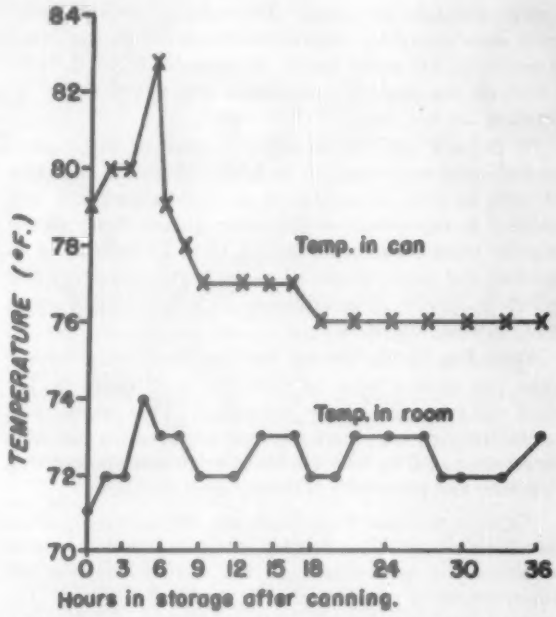

Figure 4. Increasing temperature resulting from moisture vapor absorption by CaO.

The greatly improved stability of the yeasts of low moisture levels may be attributed to the reduced rate of certain chemical reactions. It is well known, for example, that the Maillard, or browning reaction, which takes place between active aldehyde and free amine groups is inhibited at very low levels of moisture. It is quite likely that this type of reaction occurs during storage of yeast and causes inactivation of enzyme systems which are essential for viability. Thus, by reducing the moisture content to levels below 8%, stability is improved through decreasing the rates of such deteriorative reactions.

The poor performance of the bone-dry yeast made it appear that the yeast may have been damaged by the heat of reaction of water and CaO. Therefore, thermocouples were inserted in these cans in the environment in which the drying took place. The results from these tests are recorded in Figure 4. It does not seem likely that the temperatures of 79 to 83° F. prevailing within the cans of yeast for 7 or 8 hours would cause the damage observed in these almost bone-dry samples.

Speculation as to the cause of the deviation from performances of the somewhat higher moisture level yeasts is challenging. In research on adsorption and desorption phenomena observed with cellulose some workers *(7)* have attributed significance to the condition of the secondary valence of the hydroxyl groups of the cellulose molecules. In the original water-soaked condition the free hydroxyl groups are practically all satisfied by water. When the cellulose is dried these —OH groups are freed and, as a result of the shrinking, pairs are drawn together so that the individual groups of adjacent cellulose molecules mutually satisfy each other. Upon adsorption, part of the —OH groups that have mutually satisfied each other are not freed for water adsorption. In drying of yeast to the bone-dry state this phenomenon might cause unusual bindings to occur between cellulose constituents as well as the enzyme complexes. Upon rehydration, then, these cell components, perhaps, are not all returned to their original state.

Field evaluation test. The marked improvement observed in thermostability recorded in Figure 3, of 4- to 17-fold posed the question whether the extra vapor-rehydration step would fit into a Quartermaster Mobile Bakery Company schedule for producing bread. Active dry yeast has been found to be of the greatest value in overseas baking installations where bread production facilities in tents are relatively primitive compared to those available in commercial bakeries or in military garrison bakeries.

The Mobile Bakery Platoon prepares about 40 batches of dough of 492 lbs. each on a full daily schedule. Three pounds of commercial ADY are used per batch.

A field test has been conducted by the Field Evaluation Agency of the Quartermaster Corps. Its objectives were as follows:

(1) to determine whether the low moisture, thermostabile yeast may be used to product Field (Sheet) Bread without modification of existing field bakery equipment,

(2) to determine whether equal concentrations of dry yeast solids of the standard and experimental dry yeast would produce bread of comparable quality,

(3) to determine the relative performance between new low-moisture yeast and commercially available ADY, and

(4) to determine acceptance by typical Army bakers of the necessary additional treatment to rehydrate the new ADY.

The experimental yeast was prepared as follows: 3 pounds of regular active dry yeast were vacuum packed in No. 10 cans with 6 sealed Promset paper envelopes each containing 30 g. of anhydrous CaO, interspersed

evenly through the yeast. The cans of experimental yeast were stored for several months at 73° F.; an equal quantity of the same batch of commercial yeast from which the low moisture was made was stored at 45° F. pending the test date.

At the test site, the moisture content of the experimental yeast was found to be 3.5%. With the objective of using as little as possible or no new hardware, it was decided to vapor-hydrate the yeast spread evenly in the regular sheet bread bake pan of 12 x 23 inches and to conduct the vapor treatment in the regulation proof box which is capable of maintaining air conditions of about 100° F. and 90% R.H.

Spreading 3 lbs. of the low moisture yeast in the bake pan gave a layer of yeast 2½ to 3 times thicker than the early laboratory procedure. This necessitated preliminary runs to learn the time required for the yeast to return to 8.0 to 10.0%. These trial runs showed that 6 hours, and preferably 8 hours, were necessary.

Reports of these tests have not been received from the Field Evaluation Agency, so it is possible now to make only a brief report on the results based on the observations of two personnel from this laboratory. The results were encouraging in that bread of equal quality was produced by the low moisture yeast and control commercial yeast on about the same time schedule. On the undesirable side, it appeared that an extra proof box will have to be issued to each Bakery Company for exclusive use in vapor pretreatment if a round-the-clock schedule of bread production is to be maintained.

More time and study will be necessary to judge whether the added thermostability of low moisture active dry yeast will outweigh the disadvantages of the extra vapor-treatment step. It is also likely that further field tests will be necessary to determine whether the vapor-treatment step can be conducted properly under severe climatological conditions.

SUMMARY

Evidence is presented showing that active dry yeasts with moisture levels of 5.5, 4.0, and 2.2% are more thermostable than the regular commercial ADY of about 8.0%. These lower moisture levels improve the stability by factors of 4, 8 and 17, respectively. Vapor rehydration of the dried yeasts to 8.0 to 10.0% moisture was necessary before they performed efficiently in the regular bread production process.

Vapor pretreatment of the bone-dry yeasts did not reactivate them for satisfactory performance in dough preparation.

In-package desiccation was an effective method of reducing the moisture content of commercial ADY to lower levels.

Acknowledgment

The authors express appreciation for the assistance of coworkers at the Quartermaster Food and Container Institute for the Armed Forces, particularly to Lieutenant Jack A. Recca and SP-2 Thomas W. Mayo of the Chemistry and Microbiology Branch, and to Miss A. R. Felsher and Captain D. E. Donnelly of the Plant Products Branch for performing the bake tests and helping to score the bread.

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Factors Affecting Quality of Prepackaged Meat.[a,b,c] I. Physical and Organoleptic Tests. C. Organoleptic and Miscellaneous Physical Characteristics of Product

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(Manuscript received February 20, 1956)

To assist the reader in comparing the various factors under study in this phase of the experiment the following legend of codes representing the various package types used in this investigation, as given in the General Introduction, published in a previous issue, is repeated here:

Code number	Packaging material
2	Can
3	Unpackaged
4a	Vinylidene copolymer (Cry-O-Vac)
6	MSAT86 cellophane, coated both sides
6a	MSAT80 cellophane, coated side inside
6d (1)	MSAT80 cellophane, coated side outside
6w (1)	MSAT80 cellophane, coated side outside (wrapped)
8 (2)	Cellulose acetate P-912
10 (1)	Polyethylene
15	Cellophane-pliofilm laminate, pliofilm inside
16	Cellophane-polyethylene laminate, polyethylene inside
17	Cellulose acetate-pliofilm laminate, pliofilm inside
20	Trithene (wrapped)

(1) "Hand" made in the laboratory; (2) "hand" made by Celanese Corporation; all other film packages except No. 20 were "factory" made by Standard Packaging Corporation.

The containers were 5 by 6 in. pouches, made from the above materials. All pouches were sealed under 27 to 29 inches of vacuum, except package type 8 (cellulose acetate), which was sealed with a solvent at atmospheric pressure: film 15 in one run, which was sealed at atmospheric pressure; package type 6w, which was taped shut at atmospheric pressure; and package type 20, which was devoided of air as much as possible by hand pressure, folded over at the open end, and taped shut.

[a] A study of prepackaged fresh and cured meat extending through a period of five years, starting in 1949, was conducted by the Departments of Food Technology and Animal Husbandry of Rutgers University. The investigation was divided into four divisions, classified as follows: 1. physical and organoleptic studies; 2. objective color studies; 3. chemical studies related to organoleptic acceptance aside from color; 4. microbiological studies. Part I is divided into three sections, of which this paper constitutes the third. Sections IA and IB were published in a previous installment. Section IIA, Effect of Package Characteristics upon Color of Product, will appear in the next installment.

[b] A report of work conducted by contract with the Bureau of Animal Industry, U. S. Department of Agriculture, with funds provided under the Research and Marketing Act.

[c] A paper of the Journal Series, N. J. Agricultural Experiment Station, Rutgers University, the State University of New Jersey, Departments of Food Technology and Animal Husbandry, New Brunswick, N. J.

METHODS

Physical tests on meat. Physical tests included measurements (gravimetric and volumetric) of the proportion of fat and lean, penetrometer tests of fat, pH of fat, refractive index of fat, expressible juice of raw and cooked lean, and Warner-Bratzler shear tests of cooked lean.

Some of the physical tests mentioned were used only during the early part of the investigation. Physical tests, which were discontinued after Run D were (1) expressible juice, (2) Warner-Bratzler shear, (3) penetrometer, and (4) volume measurement. Results from these tests were inconsistent and no means was apparent for improving them. The Warner-Bratzler shear test was later used in a special phase of the investigation, involving a study of the utility value of a definition of texture of meat (see Part I B).

Organoleptic tests. Several organoleptic factors were initially studied. In order of ascribed importance, these were flavor, odor (cooked), firmness, tenderness, juiciness, and texture. Color and raw feel were added as organoleptic factors after Run E. Simultaneously, firmness was dropped. The group of tests, as then constituted, was carried through the project, except that texture estimation was discontinued for a period of several months, then restored to use in the later part of the project.

Organoleptic tests lacked precision, but they were regarded as giving information of value after consistency was developed by refining the techniques of these tests.

In the preliminary work and in Runs A–E, only descriptive ratings were used in making organoleptic evaluations. In Run G the use of two formal questionnaires was initiated. One of these was a numerical type questionnaire on which the judge was requested to grade the sample on the basis of the following nine characteristics:

Inside color (raw)	Odor (cooked)
Outside color (raw)	Flavor
Odor (raw)	Tenderness
Feel (raw)	Texture
	Juiciness

The other was a descriptive type of questionnaire, which called for check grading under the following list of descriptive characteristics:

Color

(both inside and outside)	Reddish brown
Dark red	Pinkish brown
Red	Light brown or grey
Pink	Dark brown

Flavor

Very desirable	Undecided (checked when other terms do not apply)
Desirable (a typically pleasant meat flavor)	Undesirable

Tenderness

Very tender	Tough
Tender	Extremely tough
Undecided	

Juiciness

Very juicy	Dry
Juicy	Extremely dry
Undecided	

These two systems were used simultaneously for the remainder of the project, although the numerical system was not put into consistent use until Run J.

The method of obtaining ratings for organoleptic quality was as follows: An organoleptic panel of from 3 to 6 judges was presented with coded samples of raw and cooked meat on separate dishes. The code designations for the samples were known only to the supervisor. At the same time, both a descriptive type score sheet and a numerical type score sheet were given to each judge. Code numbers used for the samples were shown at the top of each score sheet, while the names of the various organoleptic factors were shown along the side.

On the descriptive type score sheet, judges were asked to simply place a check mark in a box opposite the descriptive term which they considered appropriate to the sample being graded. On the numerical type score sheet, judges were asked to evaluate samples for the qualities shown by number from 1 to 10; 10 represented their estimation of what the various factors should be like in fresh or cured meat at its best, and 1 represented their estimation of what the various factors would be like when the meat had become spoiled so that it was no longer edible.

As an indication of total quality, obviously a straight sum of numerical ratings of individual organoleptic qualities would give important qualities only equal influence with the less important qualities. Therefore, it was decided to multiply the panel rating values for the different qualities by constant factors, as estimated by a committee, which were roughly proportional to the relative importance placed upon the individual qualities. This new summation was taken as a numerical estimation of overall acceptability of a sample.

The ratings given by the several judges in each examination for each quality attribute were averaged for each sample. Total quality values for each sample, both with color included and with color excluded, were determined by weighing and totaling the average ratings for individual attributes as shown below:

Average values of:	Times weight factor	Gives maximum value of:
Feel (Raw)	0.5	5
Odor	1.5	15
Flavor	2.5	25
Tenderness	2.0	20
Juiciness	1.0	10
Texture	0.5	5
Total minus color		80
Inside color (Raw)	0.5	5
Outside color (Raw)	1.5	15
Total		100

All attributes applied to cooked meat except those indicated (Raw).

Raw odor, weight loss and both objective and subjective color determinations were made before taste panel evaluations were made on the samples. Although prestige was conceded to the objective (Hunter meter) system of evaluating the samples for color, color evaluations were made by both systems through the duration of the project. In this report, the organoleptic color values are not presented separately but the ratings for color are included as a part of the "total organoleptic quality" ratings, according to the system presented above. A correlation of organoleptic color values with Hunter Color and Color Difference Meter findings, which are presented in Part II of this report, was not made.

For reasons which will be enumerated later, color is regarded as foremost in importance for consumer appeal. However, appearance aside from color is also of major importance for consumer acceptance. Appearance includes a combination of factors, some of which change during storage and some of which apparently do not. Among the latter are amount and distribution of fat and connective tissue. Texture may or may not change during storage depending partially on how texture is defined. In this investigation, no definition was established for texture, although a study was made of the utility value of selected tentative definitions of texture. (See Section 1 B.)

Possibly of third importance among the organoleptic factors for consumer acceptance is raw odor on opening packages. Raw odor for practically all samples was recorded by a single observer when each package was opened. Because odor of fresh raw samples was usually faint, panels had difficulty evaluating it. At times, raw odor was almost imperceptible. Odor data by the panel, therefore, was erratic and practically valueless. Observations of raw odor by a single observer have practical significance as indications of keeping quality, but it is recognized that they do not carry nearly as much weight as panel tests would carry were the results of these tests consistent. Because of these facts, ratings for raw odor were not used in estimating total organoleptic quality.

The factors of fourth importance, simply because the consumer encounters them in fourth order, are cooked odor and flavor. Impressions of cooked odor seem to affect flavor judgments to a considerable extent. Panel ratings for cooked odor and flavor show almost identical patterns of change over the storage period of the raw meat, extending even into the spoilage stage, although the intensity of cooked odor varies to a greater extent with small fluctuations in temperature of the specimen being evaluated than does that of flavor.

RESULTS

Samples were graded on the numerical types of questionnaire with respect to 9 organoleptic factors. The factors of *inside color, raw feel, raw odor,* and, in some runs, *texture* were not graphed separately, because their importance as criteria of keeping quality has not been well defined. Texture was graded and included in the total organoleptic quality in Runs J to V inclusive. In Runs W, X, Y and Z and AA to JJ inclusive, it was omitted, but the total organoleptic quality value was adjusted so that it was still equal to 100.

The organoleptic results other than those of *inside color, raw feel,* and *raw odor,* obtained with the numerical type questionnaire, are shown in Figures 1 through 9. Results for duplicate samples packaged in the can are shown on all graphs. For film packages, the results are from single readings. The term "standard" designates the frozen standard sample which was kept in package 15, sealed under 27 inches of vacuum, and stored at −9 to −15° F.

The values shown on Figures 1 to 9 are weighted by the weighting factors used for the various organoleptic quality attributes. Figures 1, 2, and 3 show total organoleptic quality scores (excluding those for texture) from Run S. Figure 1 shows results obtained by adding together the total organoleptic quality values for "lean" and "fat" (50% lean — 50% fat), ground pork samples. Figures 2 and 3 show separate total

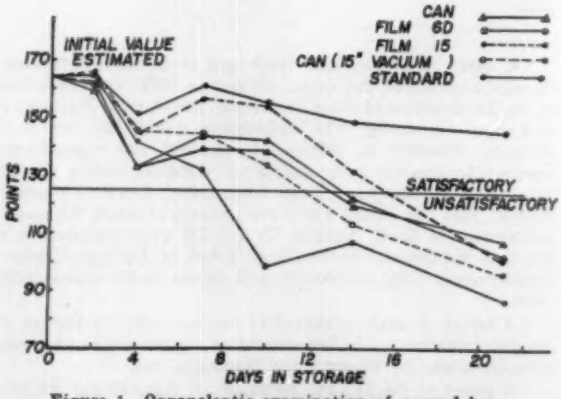

Figure 1. Organoleptic examination of ground ham. Total scores (lean plus fat) (Perfect score = 200) Run S

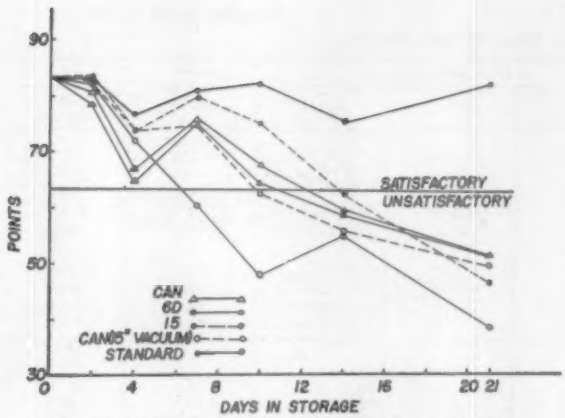

Figure 2. Organoleptic examination of ground ham.
Total scores
Lean
(Perfect score = 100)
Run S

organoleptic quality values for "lean" and "fat" ground pork samples, respectively.

Figure 4 shows values for total organoleptic quality, added with the omission of the factor of inside and outside color, separately for "lean" and "fat" (50% lean — 50% fat) ground beef samples in Run K.

Figures 5 and 6 show organoleptic color and flavor, respectively, for ground beef. Figure 7 shows cooked odor values for ground beef in Run K. Values shown in Figure 8 depict data

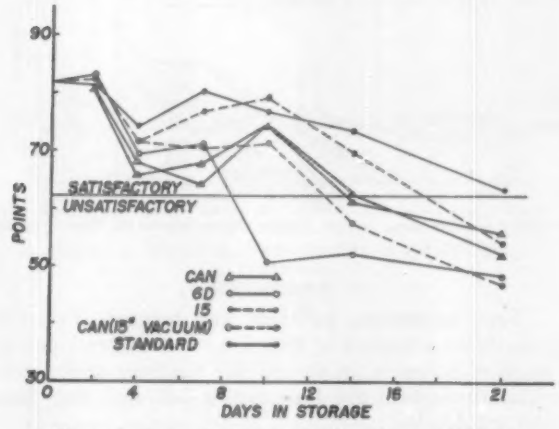

Figure 3. Organoleptic examination of ground ham.
Total scores
Fat
(Perfect score = 100)
Run S

for tenderness of ground pork in Run M. Data for Figure 9, showing values for juiciness of ground beef, were taken from Run K.

Figures 1 through 9 show horizontal lines indicating estimates of minimum acceptability values. The organoleptic panel evaluations which fall above the lines indicate acceptable or satisfactory samples with respect to the particular factor depicted, and those which fall below the lines indicate unsatisfactory samples. These lines apply uniquely to the runs with which they were used. For outside color, flavor, tenderness, and juiciness, they were estimated by finding the points on the graphs corresponding to the storage day when the panel results on the descriptive type questionnaire showed that a majority of the panel members had

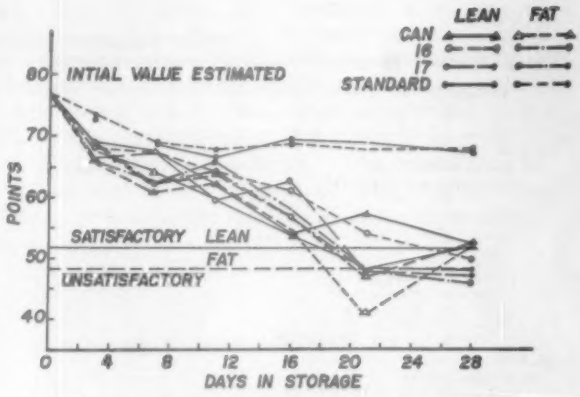

Figure 4. Organoleptic examination of ground beef.
Total (Excluding color)
(Perfect score = 80)
Run K

scored the factor in question "undecided", for some samples.

Typical results of organoleptic examinations of lean meat are shown in Tables 1 and 2. Data shown in Tables 5, 6, 7 and part of those shown in Table 3 were calculated directly from the results shown in Tables 1 and 2.

Flavor and total organoleptic quality. In Tables 1 and 2, two numerical values are given in each column for each package type. The upper figures represent total organoleptic quality; the lower figures represent flavor. These values were obtained at the times indicated as the last day of a designated storage period except those for the runs in which two examinations were made within a storage interval indicated by the column headings. For those runs, values are included which were obtained one or two days earlier than the time indicated as the last day of the period. The table does not show when this occurred.

Since the purpose of Tables 1 and 2 is to show typical results for individual runs and not the composite results of the experiments, the results for only 5 runs, viz., K, O, Q, S, and W, are given. Run W, shown in Table 2, included only one package type *(15)* besides the can control. Special treatments, indicated in the table, were involved in that run. The other 4 runs (shown in Table 1) included 6 other package types, viz., 4a, 6a, 6d, 8, 16, and 17. Eleven examinations were made in Run W during

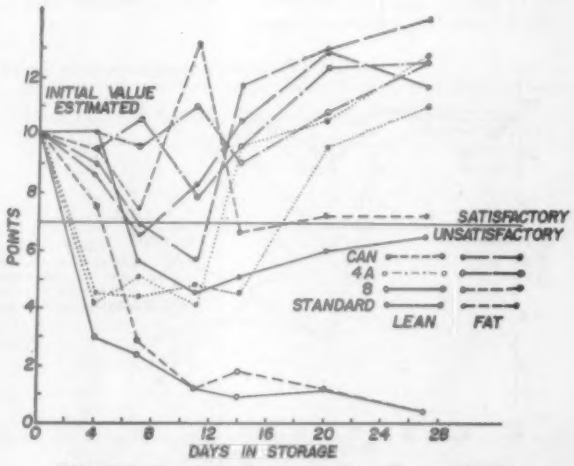

Figure 5. Organoleptic examination of ground beef.
Outside color
(Perfect score = 15)
Run O

TABLE 1

Total organoleptic quality and flavor of lean samples

Package no. and type of meat	Days of storage						
	1–2	3–4	5–8	9–14	15–21	22–28	28 and over
RUN K							
all ground samples							
Beef (grass and grain fed)							
2		75.3	76.4	70.7	71.2	74.9	70.3
		9.0	9.2	8.2	5.4	7.0	5.2
2		73.9	74.5	71.0	70.9	65.8	70.8
		9.0	8.6	7.6	5.2	4.8	5.4
16		80.5	77.4	73.8	70.1	63.6	57.4
		9.2	9.2	8.6	7.8	6.0	4.2
17		73.3	77.5	68.9	73.7	56.7	55.9
		8.5	9.2	7.6	7.6	4.2	4.0
RUN O							
all ground samples							
Beef (grain fed)							
2		69.9	67.8	67.1	57.3	73.5	66.1
		8.2	6.5	7.8	4.7	5.8	3.8
2		75.2	74.8	60.4	63.1	80.5	73.7
		9.0	9.7	7.0	7.1	8.8	8.3
4a		78.9	80.7	67.6	71.8	84.0	81.3
		8.7	8.8	8.3	8.5	8.8	8.3
8		62.0	67.3	51.1	28.4	45.0	23.2
		8.0	8.7	8.0	2.4	3.8	0.9
RUN Q							
all ground samples							
Lamb (grain fed)							
2			77.1	60.4	56.6	67.1	54.2
			8.8	7.9	6.7	9.0	6.5
2			78.3	59.4	59.2	60.3	63.2
			8.8	8.3	7.2	7.5	8.3
6a			78.7	59.4	57.6	67.1	52.9
			8.2	7.6	6.7	9.3	7.3
6d			72.8	60.4	43.2	42.7	45.3
			8.0	7.9	2.5	3.3	3.5
RUN S							
all ground samples							
Pork (grain fed)							
2	80.5	66.9	75.5	67.3	39.1	50.7	
	9.0	7.0	7.3	6.5	3.0	0.5	
2	78.4	64.6	74.9	64.1	58.4	50.9	
	9.0	6.5	8.0	5.5	2.8	0.5	
6d	81.8	71.9	60.2	47.7	54.6	38.2	
	8.8	7.5	3.8	1.5	3.8	0.5	
15	83.6	72.8	79.5	74.8	62.0	46.2	
	9.0	7.0	7.8	8.5	3.5	1.0	

Upper figure of each pair of numerical entries represents total organoleptic quality (perfect score = 100); lower figure represents flavor (perfect score = 10, unweighted).

a storage period of less than 3 weeks; 6 examinations in Runs K, O, and S; and 5 examinations in Run Q extended over a storage period of 4 weeks or longer.

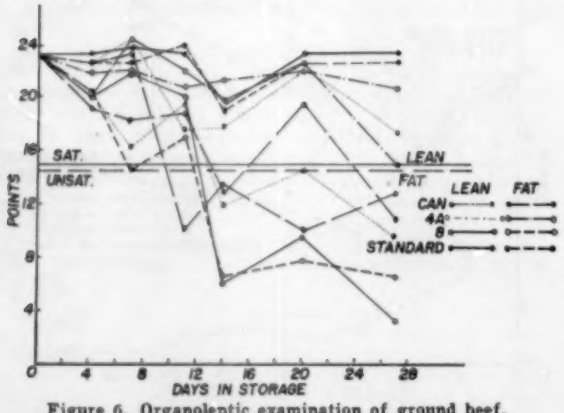

Figure 6. Organoleptic examination of ground beef. Flavor (Perfect score = 25) Run O

DISCUSSION

Feel, tenderness, juiciness, and texture. Feel was considered a method of detection of slime development. In most instances, results for feel remained almost constant throughout the runs, which indicated that slime did not develop.

Tenderness of meat is improved by enzymatic action. However, there is a critical point where further enzymatic action becomes undesirable and leads to spoilage. Therefore, as a measure of keeping quality beyond this point, tenderness should be used in an inverse way, with relatively good tenderness indicating advancement of spoilage.

Hardly enough study was made of juiciness to justify conclusions as to its value. Juiciness of raw meat seemed to follow an inconsistent trend over the storage period. It is not certain whether or not juiciness is related to drip loss. It was found in the later part of the work that when samples of beef round steak were deep fat fried, no relationship existed between juiciness and the dehydration of the samples during storage. Dehydra-

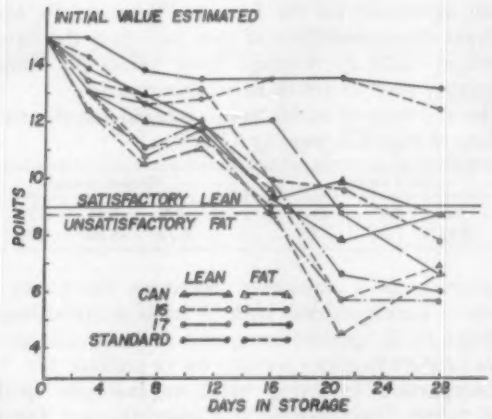

Figure 7. Organoleptic examination of ground beef. Cooked odor (Perfect score = 15) Run K

tion caused a dry appearance on the surface of the raw meat and an increase in the firmness of the raw samples, but apparently did not affect their cooked juiciness.

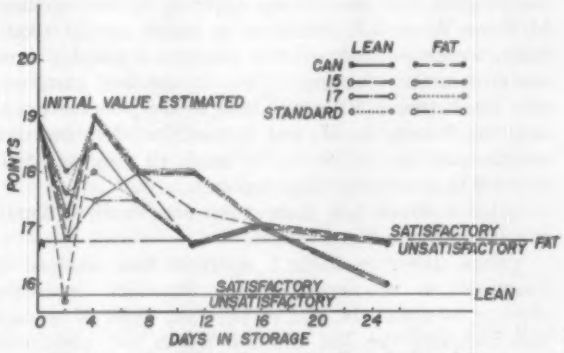

Figure 8. Organoleptic examination of ground ham. Tenderness (Perfect score = 20) Run M

Since the judges were uncertain as to just what texture is, it is difficult to say how it stood as a criterion of keeping quality. Ratings for texture, as previously stated, were not always included in the ratings for total organoleptic quality, but, when texture was omitted, the value was adjusted so that a perfect score was 100.

Package types and flavor. The reliability of techniques used in the evaluation of flavor deserves discussion. It is apparent that flavor on the numerical basis

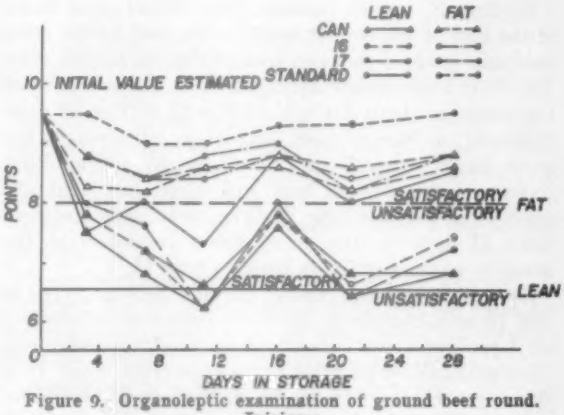

Figure 9. Organoleptic examination of ground beef round. Juiciness (Perfect score = 10) Run K

follows a fairly consistent downward trend as the period of storage of the raw meat lengthens. In addition, results with identical packaging conditions usually repeat themselves, fairly well, in different runs. Results of flavor rating also agree with other reliable indices of spoilage. Excellent negative correlations were shown between flavor and free fatty acid of fat samples for 7 consecutive runs—Runs O–U, as will be shown in a subsequent paper.

In the preliminary tests, refrigerator stored, unpackaged, fresh beef and pork, and cured ham showed good flavor immediately after purchase from the market, but

TABLE 2

Total organoleptic quality and flavor of lean samples (beef)

Package no. and type of meat	Days of storage										
	0	1	2	4	6	7	8	10	12	14	16–17
RUN W											
all cut samples											
Beef 3	89.7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	9.7										
2	.....	86.2	80.9	.....	72.5	.....	68.6	73.4	71.9	.....	68.9
		9.3	9.0	7.7	8.8		7.8	7.3	6.8		6.5
15	.....	87.9	84.0		70.7	.....	68.1	67.6	67.7	.....	60.7
		9.3	8.7	7.0	7.0		6.5	6.5	7.5		5.0
Desiccator a	.....	89.6	84.0		81.2	.....	69.1	68.8	.....	.....	.....
		9.3	9.0	7.0	8.8		7.5	7.5			
Desiccator a	.....	89.6	86.8		82.5	.....	72.9	74.3	.....	.....	.....
		9.3	9.7	8.7	9.0		7.5	7.0			
Desiccator b	.....	.....	.....	.....	.....	80.1	66.6	67.4	72.3	78.5	70.7
						9.0	7.5	6.8	7.5	8.3	6.0
Desiccator b	.....	.....	.....	.....	.....	79.6	67.8	67.1	67.2	78.6	64.5
						8.7	7.5	7.3	7.0	9.0	6.3

a—sealed and maintained at 10 cm. pressure. Samples stored inside of unsealed film 15 pouches which were stacked open end up inside of the desiccators.

b—Same as a, but the packages and samples were removed from the desiccator six days before examination, sealed under 26 inches of vacuum and held in refrigerated storage until examined.

Upper figure of each pair of numerical entries represents total organoleptic quality (perfect score = 100); lower figure represents flavor (perfect score = 10, unweighted).

slightly sour to stale flavor 3 days later. Lamb showed good flavor at both 0 and 3 days.

In Runs A–E, in which package types 2, 3, 6, and 16 were used with meat from slaughterings by the Department of Animal Husbandry, samples of lamb, grain-fed pork, and garbage-fed pork showed off-flavors in all packages by the second week of storage or by around 9 to 14 days. In all of these runs, spoilage of unpackaged samples was more advanced than that of packaged samples.

In Run F, beef in package type 15 had good flavor at the end of the second week, while beef in the other packages used in this run had off-flavors at this time. This is in approximate agreement with flavor results on the numerical basis for beef in Run G at 9 to 14 days. However, in Run H, beef samples in all packages had good flavor through the second week. Organoleptic flavor results of both beef and cured ham, cut and ground, in package type 20, were practically the same after 21 days in storage, as flavor results of similar samples vacuum sealed in package type 15.

In runs where the control can and package types 6a and 15 were compared, the flavor preservative effects of all 3 package types were about the same. Package type 15 was decidedly superior to package types 8 and 10 in flavor preservative effect. In package types 6a and 6d, or MSAT80 pouches, coated side inside and coated side outside, respectively, lean samples in package type 6a spoiled before fat samples, i.e., at 9 days, while, in package type 6d, the reverse was true.

In the runs in which package types 15 and 16 were compared, it was observed that 15 gave a slightly higher flavor value than 16. The can control samples had about the same flavor scores as samples in package type 15.

With cut pork (Run GG), over a 7-day storage period, total organoleptic quality of samples in package type 6d was generally higher than that of samples in package type 6w. With ground pork, the reverse was true. No consistent difference in total organoleptic quality or flavor was noted between the 2 packages. Averaging flavor values over the 7 days gave:

	Cut lean pork	Ground lean pork
6d	7.44	7.88
6w	7.34	8.16

In Runs HH, II, and JJ, with lamb, no consistent difference in total organoleptic quality between package types 6d and 6w was seen over storage periods of 7 to 10 days. In Run JJ, the results were in approximate agreement with those for cut and ground pork in Run GG. Outside organoleptic color, flavor, and total organoleptic quality minus color results showed no consistent agreement for the 3 runs. Flavor values, averaged for all examinations of each run, gave the figures shown in Table 3. Average flavor values for samples in package type 15 are included as a control.

TABLE 3

Flavor values of lean lamb averaged for all examinations during two weeks of storage, of runs using package types 6d, 6w, and 15

Run	Cut samples			Ground samples		
	6d	6w	15	6d	6w	15
HH	8.30	8.64		8.14	8.60	
II	7.74	7.96	7.70	7.26	7.46	8.30
JJ	8.14	8.00	7.86	8.00	8.44	8.70
Average	8.06	8.20	7.78	7.80	8.17	8.50

Flavor values of cured ham, averaged for all examinations of Run KK were as follows:

Cut samples			Ground samples		
6d	6w	15	6d	6w	15
8.44	7.88	7.76	8.72	8.70	8.64

It seems to be a reasonable conclusion that rating for flavor of packaged fresh pork or lamb or cured ham in package 6d is approximately the same as that of the same product in either package 6w or package 15.

Comparison involving total organoleptic quality and flavor. Arrangement for comparison. Table 5 shows organoleptic quality and flavor values prepared separately for beef, lamb and pork. Runs J to FF, inclusive were selected as being best adapted for use in computing these comparative average values. Owing to the fact that the runs differed from each other in respect to maximum storage periods, and to the fact that data in other respects were sometimes incomplete, not all runs in which a given species of meat was used were included in the average applying to that species. In Runs W to FF, inclusive, in which special treatments were used, only control can type 2 samples were included in the averages. Thus, in the beef category, only the 3 runs, J, K, and O, and, in the pork category, only the 3 runs, L, M, and S, contributed ratings for samples packaged in films. For lamb, all runs used contributed data on both films and cans.

Table 4 shows how many runs were used to obtain the data contained in Table 5.

Values shown in Table 5 represent data obtained in examinations at approximately one-week intervals, starting at about the end of the first week of storage and including the 2nd and 3rd weeks and sometimes the 4th week of storage.

In order to approximate the number of readings used to determine the values shown in Table 5 for film packages, the number of runs applying to the storage periods from 5 to 21 days shown in Table 4 should be multiplied by 3 and those applying to the storage periods from 5 to 28 days should be multiplied by 4. The number of runs for package type 2 should be multiplied by 6 or 8, since, with this package type, samples were always duplicated.

The primary purpose in tabulating these averages was to compare the total organoleptic quality and flavor keeping abilities of the different packages.

It should be noted that there are more data available for some package types than for others. This fact, of course, affects the validity of the comparisons.

Average flavor ratings shown in Table 5 for beef, lamb, and pork should be compared with each other by averaging the values applying to each package type only for the same storage periods. The distribution of average flavor values shown in that table in respect to package types seems to follow roughly the same pattern as that of total organoleptic quality values shown

TABLE 4

Number of runs used to obtain the data shown in Table 5

Package type	Number of runs											
	Total organoleptic quality						Flavor					
	Beef		Lamb		Pork		Beef		Lamb		Pork	
	5–21 Days	5–28 Days	5–21 Days	5–28 Days	5–21 Days	5–28 Days	5–21 Days	5–28 Days	5–21 Days	5–28 Days	5–21 Days	5–28 Days
2	8	6	4	3	7	4	8	6	7	3	7	4
4a	1	1					1	1				
6a			3	3					3	3		
6d			1	1	1	1			2	2	1	1
8	1	1					1	1				
10			1						3			
15	6	4	3	2	6	4	6	4	5	3	6	4
16	1	1			1	1	1	1			1	1
17	2	2			1	1	2	2			1	1

in the same table, with the first three and the last three package types showing generally superior performance to that of the other package types. One of the most impressive of the comparisons of flavor values shown in Table 5 is that between package types 4a and 8, both of which were included in the same run.

In order to compare the total organoleptic quality values shown in Table 5, for the different packages, it was necessary to establish a common denominator for the 3 kinds of meat used. Since the can, package type 2, was the standard sample in all runs, the total organoleptic quality values of the meats in the can were arbitrarily given a rating of 100. From the values in Table 5, ratios of comparative performance were calculated for the package types used with the different meats. For example, beef in the can had an average total organoleptic quality rating of 70.4 for 5 to 21 day storage period and that in package type 4a, a rating of 73.4 for the 5 to 21 day storage period. To ascertain the comparative performance of the two packages the following proportion was set up:

$$70.4 : 100 \pm 73.4 : x$$

A value of 104.3 was obtained for x, which indicated that package type 4a preserved the total organoleptic quality better than the can by a ratio of 104.3 to 100. Calculations on all package types were made in this way for all species of meat for the two storage periods involved.

The values obtained facilitated making an overall comparison of the packaging materials among themselves. The calculated values for the 3 kinds of meat and the overall average values by package types (unweighted in respect to kinds of meat) are given in Table 6. The overall average includes both storage periods.

Some of the packages showing good performance in Tables 5 and 6 in comparison with package type 15, for example, package types 16 and 17, did not show as good performance as 15 in retaining good color.

Comparative ratings of package types. Package types 4a and 16 with beef, 6a with lamb, and 15 with beef, lamb and pork, maintained the quality of the meat as well as or slightly better than the can control. The overall comparisons on package performance with one type of meat were similar to those with the other types. In the case of film 15, slightly better results were shown with lamb and pork than with beef, still, the rating for beef quality was high. The quality of lamb in film 6a was comparable to that in the can.

In Run O, total organoleptic quality and flavor values were slightly higher for package type 4a than for the can (control). Flavor differences between the 2 package types did not show up until the latter part of the storage period, or around 15 to 21 days. However, total organoleptic quality was higher for package 4a during the period between 3 and 8 days after packaging. It is apparent, from data of Run O, that the high score for total organoleptic quality, shown by samples in

TABLE 5

Total organoleptic quality and flavor averages by package types

Package type	Total organoleptic quality						Flavor					
	Beef		Pork		Lamb		Beef		Pork		Lamb	
	5–21 Days	5–28 Days	5–21 Days	5–28 Days	5–21 Days	5–28 Days	5–21 Days	5–28 Days	5–21 Days	5–28 Days	5–21 Days	5–28 Days
2 (Can)	70.4	69.9	71.6	69.2	73.2	72.4	7.5	7.2	7.3	6.8	7.6	7.2
4a (Vinylidene copolymer)	73.4	76.0					8.5	8.6				
6a (Cellophane, coated inside)					73.0	70.9					8.1	7.6
6d (Cellophane, coated outside)			54.2	50.2	58.8	54.8	6.4	5.7	3.0	2.4	6.9	5.7
8 (Cellulose acetate)	48.9											
10 (Polyethylene)					52.5						3.8	
15 (Cellophane-Pliofilm laminate)	70.7	69.8	72.5	70.0	74.7	74.9	7.3	7.2	7.2	6.9	6.9	6.7
16 (Cellophane-Polyethylene laminate)	73.8	71.2	63.2	60.6			8.5	7.9	7.6	6.9		
17 (Cellulose acetate-Pliofilm laminate)	69.9	63.0	60.1	58.0			7.7	6.7	7.4	6.9		

TABLE 6

Corrected total organoleptic quality averages

Package type no.	Beef		Pork		Lamb		Overall corrected averages
	5–21 Days	5–28 Days	5–21 Days	5–28 Days	5–21 Days	5–28 Days	
2	100	100	100	100	100	100	100
4a	104.3	108.7					106.5
6a					99.8	97.9	98.9
6d			75.7	72.5	80.3	75.7	76.1
8	68.0	68.7					68.4
10					77.1		77.1
15	100.4	99.9	101.3	101.1	102.0	103.4	101.4
16	104.8	101.8	89.7	87.5			95.9
17	95.0	91.4	83.9	83.8			88.5

package 4a, is produced largely by high outside organoleptic color and flavor scores. (See Figures 5 and 6). Outside organoleptic color scores of samples in the can, in Run O, were observed to decrease markedly at 4, 7, 11, and 14 days, and to return to approximately their original magnitude at 20 days. The excellent total organoleptic quality preservative effect of package 4a may have been due to the low oxygen permeability of vinylidene copolymer film and to the quality of the seal of the package. Package 4a probably had the best vacuum of all the packages, because vacuum was drawn on it while it was subjected to atmospheric pressure; consequently, it was completely deflated before it was sealed.

Films 6d, 8, and 10 did not maintain quality as well as the other packaging materials. Results with these 3 materials were almost the same. Film 6d was used with pork and lamb, film 8 with beef only, and film 10 with lamb only.

The poor organoleptic quality shown by samples in package types 8 and 10 is felt to be due to the relatively extensive exposure of the meat in these packages to the atmosphere. Package 8 was sealed at atmospheric pressure because it could not be sealed on the film package heat sealing machine and was too stiff to seal with a rubber band in the manner followed with package 4a. It showed poorer performance, at least with regard to mold growth, than package 20, which was sealed in the same manner as package type 8. A difference between the two was that film 20 was much less permeable than film 8. Flavor results of both beef and cured ham, cut and ground samples, packaged at atmospheric pressure in package 20, were practically the same after 21 days in storage as flavor results of similar samples sealed under 28 inches of vacuum in package 15. Package 10, although it had to be sealed through a protective material, seemed to take a relatively good seal. Nevertheless, it lost vacuum rapidly and showed relatively poor organoleptic keeping quality.

As might have been expected, since permeability of cellophane to air is supposed to be increased by putting the uncoated side next to the meat, the "Overall Corrected Average" (Table 6) was higher for package 6a (98.9) than for package 6d (76.1).

Total organoleptic quality scores, with respect to packages 15 and 16, followed the same pattern as flavor scores. Early in the storage period these scores were higher than those of similar samples in the control can. In Runs K and L, however, late in the storage periods, total organoleptic quality of samples in the control can was slightly better than that of samples in these two film package types. This was probably caused by the return to good color shown by samples in the can, which was not shown by samples in the films.

Package 15 was consistently better than package 17 in all respects, including organoleptic color preservative effects. The difference between these two package types was not quite as great, however, as the superiority shown by package type 4a over package type 15.

The "Overall Corrected Averages" shown in Table 6 follow a pattern which seems to correlate more with the pattern of the amount of air in the package than with any other factor studied. One of the factors influencing the amount of air in the package was the amount of space left within the package after the sample was placed in the package and the seal made. In the case of a film package, this space was not very great. In the case of the can, this space was comparatively large. With the 307 x 306 can, used in the earlier work up to and including Run T, the sample occupied a comparatively small space relative to the total volume of the can. With the 307 x 113 can, used in Runs U to LL, the samples occupied a relatively larger space, for the total volume of this can is less than half of that of the former can. In general, the sample occupied about a half of the total volume of the 307 x 113 can. In the film package, the sample occupied practically all of the space in the package. Package type 4a had the least void of all packages after sealing.

In the case of the cans, although the vacuum gauge on the can sealer read more than 27 inches most of the time, a vacuum of 25.5 inches was about the highest registered on the test gauge used to measure vacuum in cans before opening. In other words, there was a loss of approximately 1.5 inches from the vacuum in the sealing chamber. This was partially due to reduction of the internal volume of the can after sealing because of the ends being drawn by vacuum. In the case of the film packages, there was also a "squeezing in" of the vacuum-sealed package as soon as atmospheric pressure was admitted into the sealing chamber which previously had held vacuum equal to that which was in the film package. The "squeezing in" increased the pressure, i.e. decreased the vacuum, inside the package, but to what extent was not ascertained. All that can be said about the amount of vacuum inside the film package is that the packages were sealed under a specified vacuum, which was somewhat higher than the vacuum inside the package at the time of storage, and that the samples were observed carefully during storage for any visible indications of loss of vacuum.

All package types for total organoleptic quality and flavor. Flavor and total organoleptic quality values are treated as evidence bearing on the preservative effect of the packages used in this project A comparison of packages based on these factors, as treated in the preceding discussion, is given in Table 7, using descriptive terms for the comparisons. This comparison is based on data presented in Tables 5 and 6.

Special comments on package types. A slight odor, apparently originating from the package film material

TABLE 7

Classification of packages in respect to preservation of flavor and total organoleptic quality of fresh meat

Classification	Flavor	Total organoleptic quality
Superior	4a, 6a	4a
Excellent	16	
Very Good	2, 15, 17	16
Good	6d (lamb)	2, 6a, 15, 17
Fair		
Mediocre	6, 8	
Poor		6d, 8
Very Poor		10
Other	Extremely poor: 3, 6d (pork), 10	

itself, was often observed in the raw samples on opening the packages, especially with samples in package type 15. This odor was so slight that no record was made of its presence until Run JJ when the question arose as to whether or not any of the package films investigated gave odor to the samples. Subsequently, a definite record was made of the presence of such off-odor on both cut and ground lamb samples. In Run JJ, the samples, which contained 15 to 20% fat, were stored at an average temperature of 43° F. in package 15, and notations indicating the presence of a slightly "off" raw odor were made at 3 and 6 days of storage. In this run, examinations were made at 1, 2, 3, 6, and 7 days. No "off" odor was detectable after the meat of Run JJ was cooked.

Cured ham in Runs KK and LL, showed no odor from the film of package type 15. The only organoleptic examination made in Run LL was after 21 days' storage, by which time the samples had developed somewhat strong odors from spoilage.

In Run LL, trithene, or package 20 was used. It was made of a relatively thick, quite strong, flexible, very slightly cloudy material, requiring sealing at high temperatures for a short exposure time, as furnished by "impulse" sealers. Attempts to seal it on an ordinary heat sealer were unsuccessful so the pouches were folded over after excluding as much air as possible, and taped shut.

Packaging materials with low oxygen and carbon dioxide permeability appear to favor general organoleptic keeping quality, as shown in Tables 1, 2, 3, 6 and 7.

Effects of variations in treatment technique of meat.[4] Keeping quality of cut samples was noticeably better than that of ground samples.

"Fat" ground meat, ranging in fat content from 10 to 50%, generally received higher quality ratings than lean ground meat. Whether this was caused by natural preference or better keeping quality was not evident. Most likely both were responsible. At any rate, in one 28-day run with pork, when extra fat was included in the package with cut lean samples, total organoleptic quality, both with and without color, was higher than that of the samples without fat. With pork frozen for 4½ weeks before thawing and packaging, there was no material difference in quality ratings between samples packaged with fat and those without fat.

In general, it seems that, under anaerobic conditions, "fat" samples have better keeping ability than lean. Under aerobic conditions, the reverse appears to be true.

Flavor values of beef cut samples from one round were slightly higher over a 2-week period than those of similar samples from the other round of the same animal, which had been frozen as wholesale cuts and held for 19 days before packaging. The storage temperature was about 38° F. in both instances.

In a second set of two consecutive runs, fresh hams of two hogs were used in the first run, while hams and shoulders of two other hogs, slaughtered on the same date, were cut into large chunks, held at −9 to −15° F. for 21 days and then used in the second run. Storage temperature was 40° F. in the first run and 43° F. in the second. The storage period was 2 weeks in each run in which cut samples were used. Flavor values of samples in the first run were slightly higher, over most of the storage period, than they were in the second run.

In still another set of two consecutive runs, hams of two hogs were used in the first run, while hams of two other hogs, slaughtered on the same date, were cut into chunks, held at −9 to −15° F. for four and one-half weeks, and then used in the second run. Cut samples were used. In each run, the storage period was four weeks and the storage temperature was 45.5° F. Flavor values of lean samples in the second run were slightly higher in the first two weeks of storage than were those in the first run, but about the same in the 3rd and 4th weeks. Flavor values of "fat" samples were about the same in both runs over the entire storage period. The "fat" samples were slices containing portions of lean and fat in approximately a 3 to 1 proportion.

Fifteen inches of vacuum in the can. Over a 3-week storage period, 15-inch vacuum storage in the can at 40° F. was almost as good as 27-inch vacuum storage in preserving total organoleptic quality of both lean and "fat" ground pork samples where the "fat" samples were about 50% lean and 50% fat. Outside organoleptic color of samples under 15 inches was decidedly better at 2 and 4 days, but samples under 25 inches were better at 10 and 14 days.

Flavor values of lean samples in the 15-inch vacuum can were about the same as those of the can control samples (27-inch vacuum) through a 3-week period. Flavor of "fat" samples sealed in a 15-inch vacuum, over the entire storage period, was slightly better, on the average, than that of similar samples in the control can.

Outside organoleptic color values of ground lean and "fat" (50% lean-50% fat) lamb samples stored at 42° F. in 15-inch vacuum sealed cans was slightly better during the first 14 days of storage than those of similar samples stored in 27-inch vacuum sealed cans. At 21 days, the end of the storage period, the latter were better. Flavor was about the same for the two packages, except at 21 days, when the samples sealed under 27 inches of vacuum were better. In other runs, however, in which vacuum in cans was reduced by

[4] Broad comparisons, developed statistically from the mass of data of this project, of the effects of some of the variables discussed in the following paragraphs preceding the summary, are presented in Part V of this report.

leakage during storage, samples in high vacuum did not become rancid as rapidly as those in cans that leaked.

In summary, in storage periods of less than 2 weeks, storage in 15-inch vacuum sealed cans appeared as good, or possibly slightly better, than storage in 27-inch vacuum sealed cans, with regard to total organoleptic quality preservation. With longer storage, the latter were better in this respect.

Achromobacter inoculation.* Over a 3-week storage period, at 40° F., no substantial difference was noted in flavor of "fat" (50% lean and 50% fat) ground pork samples between uninoculated samples and samples inoculated with *Achromobacter sp.* The inoculated samples in package types 2, 6d, and 15 showed a characteristic odor all through the run. At 21 days, non-inoculated "fat" samples in those same packages had a similar odor, indicating that this microorganism would be primarily involved in any spoilage which might occur in noninoculated samples.

Antioxidants. Ground lamb samples, with 0.1% by weight ascorbic acid added, appeared better in outside organoleptic color than non-treated samples. This was more noticeable in "fat" samples than in lean. In this respect, 0.1% was better than 0.25%. Little difference in overall organoleptic quality, other than color, was shown between treated and non-treated samples.

With lean cuts of beef stored for 3 weeks at both 36° F. and 45° F., outside organoleptic color was slightly better for samples treated with 0.05% ascorbic acid applied in dry powder form in 3 portions by churning for a total of 10 minutes, than for non-treated samples. In the same runs, the latter were slightly better than samples having a 0.1% level of treatment. In some cases, color difference between the 2 treatments was fairly pronounced in favor of the lower level of treatment, especially at 4 days. No consistent difference was seen in flavor values. At both storage temperatures, total organoleptic quality minus color values was in reverse order to the organoleptic color values, although the difference was small.

When 0.5% ascorbic acid was added (in dry powder form) it caused an immediate darkening of lean cut samples of beef. The color was a very dark reddish brown such as sometimes occurs with non-treated beef in the natural course of storage. This color remained for all of a 21-day storage period.

With or without the addition of 0.1% antioxidant N.D.G.A., lean ground lamb samples, at the end of a 2-week storage period at 38° F., were about the same in outside organoleptic color. "Fat" (50% fat-50% lean) treated samples, after 2 weeks, were more pale, but about the same in redness as non-treated samples. Flavor of non-treated lean samples was somewhat better over the 2-week period than flavor of treated lean samples in film 10, while treated and non-treated samples in the can and in film 15 were about alike in flavor. Flavor of the treated "fat" samples in film 15 was somewhat better than that of the non-treated samples in film 15 over the whole storage period. With "fat" samples in film 10 and in the can, treated and non-treated samples were alike in flavor.

Storage at room temperature. Outside organoleptic color of "fat" (50% lean and 50% fat) ground lamb samples in cans was somewhat better over a 3-week storage period at 36° F. after having been held at room temperature for 20 hours before storing, than it was for similar samples stored immediately after packaging. Flavor values of "fat" samples were somewhat better over the whole storage period if stored at 36° F. right after packaging.

Lean samples were about the same in flavor and in outside organoleptic color for these 2 types of storage over the 3-week storage period.

Outside organoleptic color values of lean and "fat" ground lamb samples were much higher, for the whole run, for can samples held at room temperature for 42 hours before being placed in the storage cabinet at 42° F. for the 3-week storage period than they were for similar samples stored immediately after packaging. Flavor values for the former samples were much lower over the entire 3-week storage period than those for the samples that were stored immediately after packaging.

Storage at 34° F. vs. 40° F. In general, total organoleptic quality, flavor, and organoleptic color of all meats were maintained better at relatively low temperatures. Storage at around 34° F. was better in prolonging good quality life of fresh lamb from grain fed animals, than storage at 40° F. This was shown by two consecutive runs, Q and R, between which temperature was the only variable.

Storage—light vs. dark. There was no noticeable difference in the retention of organoleptic quality between fresh meat under light and that under dark storage. Fresh pork samples in film packages half-masked with tape and exposed to 65 foot candles of mixed fluorescent and daylight for a period of longer than 3 weeks showed no difference in visual color between the 2 halves.

Cured ham showed a pronounced greying of color in 30 foot candles of light at 38° F. within 2 days, which did not take place in the dark. There was no marked effect of light on any of the other organoleptic factors in these samples even during 21 days of storage except for an acetic-acid-like odor which developed in samples packaged at atmospheric pressure in package 20. This was not noted with packages 6d and 6w; however, these were not stored beyond 7 days. The odor was absent in package type 20 samples stored in the dark.

After 21 days, a cut sample of cured ham in package 15, sealed under vacuum and stored in the light, had good color, while a sample in package 20 (closed in air) was quite grey. All dark stored cut samples had good color. All ground samples, both light and dark stored, had a grey color at 21 days, with the exception of the can control sample.

SUMMARY AND CONCLUSIONS

Package types. Ground lean beef, lamb, and pork

* The procedure followed in Achromobacter inoculation will be described in Part IV of this report, where will also be given a further discussion of the effects of this inoculation upon organoleptic quality of the meat.

samples in film packages were stored at temperatures of 32° to 40° F. and examined at approximately weekly, or in the case of pork, shorter, intervals for a period of three to four weeks. Better flavor and total organoleptic quality were shown when they were stored in films having a relatively low oxygen and water vapor permeability, than when they were stored in films having relatively high permeability. Whether a slight amount of permeability in package films is desirable or not is still in question.

Cut and ground lamb samples, both containing 15 to 20% fat, were stored over a 7 to 10 day period at 35° to 43° F., and examined either daily or every two days. Over a given storage period, flavor of samples stored in MSAT80 cellophane, coated side out, pouches, sealed at 26 to 28 inches of vacuum, was about equal to that of samples wrapped, but not sealed, in the same material and of samples in cellophane-pliofilm laminate pouches, sealed at 27 to 29 inches of vacuum.

Fresh vs. frozen meat. Three sets of two consecutive runs each—the first set with beef, the second and third with fresh hams—were made to study the effects of freezing meat before packaging. In the second run of each set, meat of similar origin to that used in the first run, and slaughtered at the same time, was used but this meat was frozen in chunks on the packaging day of the first run and held at from —9° F. to —15° F. until it was thawed on the day before it was packaged. Cut samples were used in all runs.

In each of the first two sets of runs, flavor values of samples in the first run were slightly higher over most of the storage period than those in the second run. In the third set of runs, flavor values of lean samples in the second run were slightly higher in the first 2 weeks of storage than they were in the first run, but about the same in the third and fourth weeks. Flavor values of "fat" samples were about the same in both runs over the entire storage period.

Vacuum. Panel ratings for flavor of lean and "fat" (50% lean-50% fat) ground lamb samples and of similar pork samples, stored in 307 x 306 cans, were about the same over a 2-week storage period when the cans were sealed at 15 inches of vacuum as they were when the cans were sealed at 27 inches of vacuum. Lamb samples carried beyond 2 weeks showed better results in the 27-inch vacuum storage.

Achromobacter. *Achromobacter sp.* inoculation had practically no effect on panel ratings for flavor of "fat" (50% lean-50% fat) samples of ground pork over a 3-week storage period at 40° F. Throughout the storage period, however, a characteristic odor was noted with these samples in the raw state, which was not present in the non-inoculated samples. Lean samples were not inoculated.

Ascorbic acid. Ascorbic acid, in the dry powder form, did not have any substantial effect on overall organoleptic quality, other than color, of meat stored for 2 to 3 weeks at 36° F. to 45° F.

Fat. When containers of low fixed gas permeability, sealed under 27 to 29 inches of vacuum were used, the presence of some fat in the meat seemed to cause slightly better retention of overall acceptability of the meat during storage of 3 to 4 weeks at temperatures of 34° F. to 42° F. than was found in all-lean samples.

Temperature. During storage periods of 3 to 4 weeks, temperatures close to 32° F. prolong desirable flavor of meat better than temperatures around 40° F.

Organoleptic panel evaluations of flavor of lean ground lamb samples, stored in cans sealed at 27 inches of vacuum, were about the same during a 3-week storage period at 36° F. when the samples were stored immediately after packaging as when they were held at room temperature for 20 hours after packaging. "Fat" samples of ground lamb had a slightly better flavor during storage when they were stored immediately after packaging.

Light. With fresh meat it is practically immaterial, from the standpoint of overall organoleptic quality, whether during storage the meat is exposed to light or not. There was no marked effect of light on any of the organoleptic factors, other than color of cured ham stored at 38° F. even up to 21 days, except for an acetic-acid-like odor which developed in samples packaged in unsealed trithene pouches exposed to 30 foot candles of light. This same odor was not noted in cured ham samples packaged in the same film, unsealed, but stored in the dark at the same temperature as the samples exposed to the light. The odor was present only in raw samples.

Use of the Automatic Green-Rot Detector to Improve the Quality of Liquid Egg

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THE EGG PROCESSING INDUSTRY is constantly striving to minimize the number of rots among eggs used as breaking stock. The tremendous number of bacteria which can be introduced into liquid egg products by a few spoiled eggs emphasizes the need for developing better means to exclude them. At present, white light candling of shell eggs is used to supplement organoleptic examination of egg products on the breaking line, especially in warm weather when incidence of spoilage tends to be high. A candling procedure that is gaining favor in commercial egg receiving stations employs long-wave ultraviolet light to detect an important type of spoilage, the so-called "green rot" that frequently cannot be recognized by visible light candling. For purposes of this study, the term "green rot" denotes any shell egg which exhibits green fluorescence. This term, therefore, includes those eggs commonly called "fluorescent sours" as well as eggs showing advanced stages of decomposition which exhibit fluorescence. This detection is possible because the bacteria involved in this type of spoilage produce a substance which causes the albumen of the egg to exhibit a bright green or bluish green fluorescence under ultraviolet light. This property is utilized in "black-light" candlers for shell eggs, and in special ultraviolet lamps to inspect egg contents at the breaking line.

An automatic photoelectric apparatus for detecting green-rot fluorescence has recently been developed by U. S. Department of Agriculture scientists. Evaluated under laboratory conditions, using visual examination of broken out eggs as the criterion, it was found to be 100% accurate in detecting and rejecting green-rot eggs, and 97.6% accurate in accepting nonfluorescent eggs *(3)*. The machine operates at a rate of 1,000 eggs per hour.

The purpose of the study reported here was to evaluate the performance of the machine in a commercial egg breaking plant. It was intended to determine how the use of the machine affected the bacterial condition of edible liquid egg products in both the spring and summer seasons, and secondly, to determine the efficiency of the detector in rejecting fluorescent eggs under commercial conditions.

MATERIAL AND METHODS

The experiments were conducted in a commercial egg breaking plant during the month of April (1956) and then repeated in the same plant in July (1956).

Selection of the sample. In order to increase the probability of obtaining a high proportion of green-rot eggs in these studies, shell eggs of extremely low quality, according to shell egg standards, were purposely selected for use as breaking stock. Candling of the individual eggs was also omitted for this reason. The cases of eggs selected contained eggs of various shell colors ranging from white to dark brown. (No effort was made to determine the relative proportion of eggs of each shell color in these cases.)

For each set of experiments (April and July), three 20-case lots of eggs (one lot for each of the three treatments described below) were prepared by the use of a systematic stratified sampling technique, so that the lots were considered to be qualitatively and quantitatively equivalent. These lots were prepared the day prior to the first run of each period. All leaking eggs, peewees, and extremely dirty eggs were replaced with clean, sound, medium or large eggs, but no attempt was made to locate and replace all cracked eggs. The eggs were subsequently placed in a cold storage room at 7° to 10° C., the appropriate number of cases being removed daily from each lot as required for the experimental runs.

Treatments. For each period (April and July), each of the three treatments was repeated twice a day for five days, resulting in 10 experimental runs. Within each run, two cases of eggs were used for each treatment.

In the first treatment, the eggs were passed through the detector. All eggs accepted by the detector were broken, organoleptically examined by the breaker, and separated into albumen, yolk, mix (eggs in which the yolk membrane broke upon attempted separation), and tanners (eggs considered inedible by organoleptic examination). This treatment is hereinafter referred to as "combination" treatment.

The second lot of eggs was also passed through the detector. The accepted eggs, however, were not organoleptically examined so that albumen, yolk, and mix were the only products obtained in this treatment, i.e., tanners were considered as edible. This treatment is hereinafter referred to as "machine only" treatment.

In the third treatment, the eggs were not passed through the detector, but were broken, organoleptically examined, and separated into albumen, yolk, mix, and tanners. This treatment corresponded to the routine procedure employed in a commercial egg breaking plant and is hereinafter referred to as "organoleptic only" treatment.

In the combination and machine only treatments, the detector was set to reject all eggs which exhibited a degree of fluorescence sufficient to cause a voltmeter reading of 3.5 volts or higher *(3)*. Eggs rejected by the machine were replaced with eggs previously found green-rot free by the machine. All rejected eggs were collected for further study.

The breaking, separating, and organoleptic examination operations were performed by experienced egg breakers. Standard breaking line procedures were used throughout, except that in the machine only treatment, an organoleptic examination was not made. The albumen and yolk from each treatment and run were collected in clean 10-gallon milk cans. The mix and tanners were collected in clean 30-pound capacity trade containers of the type used for frozen egg products.

Bacteriological sampling and analysis. The albumen in each can was agitated with a ladle after which a sample was taken and put into a sterile glass quart jar. The yolk and mix were stirred with an electric mixer, and a sample of each was ladled into a sterile glass quart jar. The tanners were not sampled for bacteriological analysis.

The mixer and ladle were washed in a detergent solution, rinsed in clean water, and finally rinsed in a sodium hypochlorite solution (200 p.p.m. of chlorine) before taking the sample from each can.

The jars were placed in a cold storage room at −40° C. for approximately one-half hour which sufficed to chill the samples without freezing them. They were then placed in insulated sample carriers and transported by automobile from the breaking plant to the laboratory (about 25 miles).

The bacteriological analyses for the April period consisted of plating serial dilutions of the albumen and yolk to 1 : 10,000 and of the mix to 1 : 100,000. For the July period, the serial dilutions included 1 : 100,000 for the albumen and yolk, and 1 : 1,000,000 for the mix. Phosphate buffered saline was used as the diluent and tryptone glucose extract agar was the medium

selected for plating. The plates were incubated at 30° C. for 48 hours.

The plate counts were expressed as numbers of bacteria per milliliter of egg product and were derived in accordance with standard methods *(1)*.

RESULTS AND DISCUSSION

The bacteriological results [a] for all products and treatments for both the April and July periods are recorded in Table 1. Table 2 summarizes the results of the analyses of variance and the multiple range tests *(2)* applied to the data.

TABLE 1

Bacterial counts of liquid egg products from shell eggs found acceptable by three evaluation procedures (Thousands per milliliter)

Product and experimental run	April experiments			July experiments		
	Combination [1]	Machine only [2]	Organoleptic only [3]	Combination	Machine only	Organoleptic only
Albumen:						
1	4	3	1,100	2,700	1,200	2,400
2	8	44	3	1,000	2,200	3,200
3	12	3	27	1,200	1,700	1,700
4	3	5	3,000	1,600	3,000	9,000
5	17	16	14	4,400	8,600	10,000
6	3	320	490	1,400	11,000	27,000
7	270	470	570	6,200	8,600	15,000
8	30	2,000	140	1,500	3,400	2,500
9	140	160	160	1,700	5,200	10,000
10	14	390	1,300	6,700	16,000	4,100
Geometric mean	16	60	180	2,300	4,800	5,900
Yolk:						
1	3	3	830	2,600	2,800	6,600
2	390	14	3	7,300	9,000	31,000
3	8	6	3	510	780	2,600
4	3	13	660	940	1,400	1,500
5	3	3	11	750	17,000	4,700
6	3	650	170	1,400	7,500	770
7	3	3	320	4,100	6,100	12,000
8	7	600	490	340	520	4,700
9	250	11	260	370	1,200	6,000
10	3	3	360	2,700	4,400	2,700
Geometric mean	9	14	100	1,400	3,000	4,400
Mix:						
1	10	6	28,000	8,800	240,000	69,000
2	6	23	6	7,300	250,000	120,000
3	35	13	40	2,900	31,000	9,200
4	28	480	560	21,000	63,000	71,000
5	49	61	47	18,000	140,000	23,000
6	23	9,900	210	91,000	36,000	14,000
7	91	12	80,000	38,000	40,000	89,000
8	6	1,100	250	10,000	18,000	43,000
9	1,300	330	1,100	3,400	34,000	38,000
10	4	130	13,000	15,000	140,000	6,300
Geometric mean	27	110	630	13,000	68,000	33,000

[1] "Combination"—accepted by detector and by organoleptic examination.
[2] "Machine only"—accepted by detector (no organoleptic examination).
[3] "Organoleptic only"—accepted by organoleptic examination (not passed through detector).

With the exception of the mix in the July experiments, the average (geometric mean) bacterial counts of the machine only products were always lower than those of the organoleptic only products. However, the statistical analysis revealed that the differences between these two products in both periods of the experiment were not significant.

[a] As a consequence of the purposeful selection of low quality eggs for the study, the bacterial counts reported here should not be interpreted as being representative of counts in commercial liquid egg products.

TABLE 2

Significance of differences between geometric means of bacterial counts (from analysis of variance)

Treatment	April experiments			July experiments		
	Albumen	Yolk	Mix	Albumen	Yolk	Mix
Combination versus machine only	n.s.	n.s.	n.s.	(*)	(*)	(**)
Machine only versus organoleptic only	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Combination versus organoleptic only	(*)	(*)	(*)	(**)	(**)	(**)

n.s.—indicates no significance.
(*)—indicates significance at 5% level.
(**)—indicates significance at 1% level.

The combination of automatic green-rot detection and organoleptic examination proved to be better than organoleptic examination alone. The differences between the average counts of the products from these two treatments for both April and July are given in Table 3. Each difference expressed as a percentage of the organoleptic only count is also shown. As was expected, the bacterial counts of all liquid egg products were significantly higher in July than in April (analysis of variance not shown).

The detector rejected 264 eggs from 40 cases (1.8%) in April and 675 from an equal number (4.7%) in July. Despite this increase in the number of eggs rejected by the machine, the differences between the average counts of the combination and the organoleptic only treatment products in July were about 30% less than in April. Apparently, the increase in the degree of contamination from fluorescent eggs in the summer was not as great as the increase from other sources.

It will also be noted that there was a significant difference between the combination and machine only treatments in July, although not in April. This indicates that the effect of organoleptic examination in the summer was greater than in the spring, and as a corollary, that liquid egg contamination from eggs detectable by organoleptic examination but not by the machine was greater in the summer. This was particularly evidenced by the extremely high bacterial counts of the mix from the machine only treatment in July.

Eggs rejected by the detector in the combination and machine only treatments in April plus rejects from five additional cases totaled 297 (1.8%). Only 46 eggs

TABLE 3

Effect of supplementing organoleptic examination of shell egg contents with automatic green-rot detection on the bacterial condition of liquid egg products

Period and product	Bacterial counts (geometric mean)		Percent difference
	Organoleptic only	Combination	
	(Thousands per milliliter)		
April:			
Albumen	180	16	91
Yolk	100	9	91
Mix	630	27	96
July:			
Albumen	5,900	2,300	61
Yolk	4,400	1,400	68
Mix	33,000	13,000	61

(0.3%) of all the eggs examined by the detector actually fluoresced when broken out under a black light. Since a significant difference was found when the machine was used in combination with organoleptic examination, it is evident that very few green-rot eggs per case can markedly increase the bacterial counts of liquid egg products. Evidence that bacterial counts of individual fluorescent eggs may be of the order of millions or billions *(4)* substantiates this contention.

Prior to breaking out, the shell color of each rejected egg was recorded. Table 4 gives the number of eggs

TABLE 4

The relationship between shell color and fluorescence in the contents of eggs rejected by the detector (April)

Shell color	Number rejected	Number showing fluorescence when broken out	Percent of rejects showing fluorescence when broken out
White	38	26	68.4
Tinted	13	5	38.5
Light brown	95	11	11.6
Brown	76	4	5.3
Dark brown	75	0	0
Total	297	46	15.5

of each shell color rejected, together with the number in each class which fluoresced when broken out under the black light. Since the proportions of eggs of each shell color in the original lots were not known, these figures do not indicate the relative incidence of fluorescent eggs among the various shell color classes. The data presented in Table 4 indicate that refinement of the detector is necessary in order to minimize the occurrence of false positives, particularly among brown shelled eggs.

In the July period, a total of 675 eggs from 40 cases (4.7%) was rejected by the detector. As previously noted, the machine was set to reject all eggs which induced a meter reading of 3.5 or more volts. The rejects from each run and treatment (combination and machine only) were rerun through the detector at a reject level of 6.0 volts. These eggs were thus separated into two groups, i.e., those which caused readings between 3.5 and 6.0 volts (acepted by the machine at this setting) and those showing readings of 6.0 volts or higher. A total of 204 eggs (30.2%) gave readings between 3.5 and 6.0 volts while the remaining 471 eggs (69.8%) gave readings of 6.0 volts or higher.

A bacteriological analysis of the yolk from each individual group of rejects (run, treatment and meter reading) was then made. The results of this study are given in Table 5.

An analysis of these data indicated that there was a significant difference ($p = 0.05$) between the two reject level groups, with the eggs rejected at the 6.0 volt level showing a greater average bacterial count. This suggests a possible relationship between the degree of fluorescence which an egg exhibits and the number of bacteria in that egg. However, because of the dilution effect exerted by any false positives which may have been included in the groups, particularly at the lower reject level, definite conclusions regarding individual eggs cannot be made.

TABLE 5

Bacterial counts of yolks from groups of eggs rejected by the detector at two different reject levels

Experimental run	Reject level	
	3.5 volts	6.0 volts
	Bacteria/ml. (millions)	Bacteria/ml. (millions)
1a	40	290
b	130	55
2a	3	30
b	6	67
3a	74	130
b	390	860
4a	500	42
b	350	220
5a	4	1,500
b	3	260
6a	14	170
b	130	1,000
7a	33	84
b	430	93
8a	3	200
b	29	140
9a	180	180
b	14	190
10a	3	210
b	120	180
Geometric mean	36	170

The significance of fluorescent and nonfluorescent types of spoilage in shell eggs was investigated by Trussel *(4)*. His conclusion that nonfluorescent types of spoilage are of greater importance than is generally recognized is supported by our investigations. His criticism of the commercial use of ultraviolet light candling of shell eggs (inability to detect nonfluorescent and low levels of fluorescent infections, the occurrence of false positives) would be only partially applicable to the use of the detector in egg breaking plants. This machine is able to detect eggs with levels of fluorescence much lower than the levels detectable by visual ultraviolet light candling. In addition, further improvements of the machine which will minimize the number of false positives are currently being studied so that this shortcoming may be overcome. In spite of its present limitations, the use of the detector as an adjunct to organoleptic examination in reducing the extent of liquid egg contamination appears to be of great value.

SUMMARY AND CONCLUSIONS

The performance of the green-rot detector and its effect on the bacterial condition of edible liquid egg products were studied in a commercial egg breaking plant in the spring and summer.

This apparatus when used alone showed a slight, although not significant, tendency to be more effective in lowering bacterial counts than organoleptic examination alone. When the detector was used as a supplement to organoleptic examination, however, the bacterial counts of the liquid egg products were significantly lower than when organoleptic examination alone was made. This combination of the two devices was of more value in the spring than in the summer, indicating that liquid egg contamination from green-rots was proportionately greater in the spring than in the summer.

The combination of automatic green-rot detection and organoleptic examination proved to be more effective than the use of the detector alone in the summer but not

in the spring, indicating that sources of contamination other than green rots are of greater importance in the warmer season.

Examination of broken out machine rejected eggs under a black light revealed that the incidence of green rots in April was quite low (0.3%). It is concluded that very few (possibly only one) green rots per case of eggs may suffice to markedly increase the bacterial counts of liquid egg products.

It was found that the percentage of false positives among eggs rejected by the detector was greatest for eggs with dark brown shells, and least for white shelled eggs.

The average bacterial count of groups of eggs showing a high degree of fluorescence was significantly greater than those exhibiting a low degree.

Acknowledgment

Acknowledgment is gratefully made to Henningsen, Inc., Springfield, Missouri, for providing laboratory facilities; to Continent Frozen Food Company, Marionville, Missouri, for allowing the experiments to be conducted in its plant, and to Dr. Richard Forsythe and staff, Central Laboratories, Henningsen, Inc., Springfield, Missouri, for their cooperation and assistance.

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Factors Affecting Freezing Rates of Poultry Immersed in Liquid[a]

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(Manuscript received March 2, 1957)

The light surface appearance of poultry frozen by immersion in liquid together with fast freezing and efficient use of refrigeration has led to increasing interest in immersion freezing for the poultry industry. Results of previous experiments show that lightness of appearance of frozen poultry is related to freezing rate and indicate that any desired degree of lightness can be obtained with temperatures above —20° F. *(6).* The effect of liquid temperature and weight, initial temperature of bird and packaging material on freezing rate have also been determined *(6),* but little information is available about freezing rates using different liquids and rates of agitation under comparable conditions.

The main object of the work reported here was to measure freezing rates in several liquids with widely differing physical properties over a wide range of agitation rates. Since results of previous tests *(6)* indicated that the large variability in freezing times of comparable birds would necessitate a large number of replicates to ensure reasonably precise results, models rather than actual birds were used in this work. The models were also used to obtain more precise results on the effects of liquid temperature, bird weight, initial temperature of bird and packaging on freezing rate than those obtained earlier with chickens and turkeys *(6).*

Test results are compared with results calculated from Plank's freezing equations *(11, 12),* and heat transfer coefficients are calculated from the measured freezing times using these equations.

[a] Contribution from the Division of Applied Biology, National Research Laboratories, Ottawa.

EXPERIMENTAL

Models were frozen in a cylindrical 50-gallon tank, 26 in. in diameter, equipped with a direct expansion cooling coil and an adjustable stirrer. The initial temperature of the models was 32° F., except where the effect of higher initial temperature was studied.

Four rates of agitation (Table 1) were tested with each of 5 different liquids (Table 2) at —20° F. Rates of agitation and liquids were selected to cover the range of conditions of probable commercial interest. The physical properties of the liquids used are given in Table 2 to facilitate application of the results to other liquids with different physical properties. Additional tests, to determine the effects of size, initial temperature and packaging of model as well as liquid temperature were made in the calcium chloride and glycerol solutions.

Most tests were made with a cylindrical Cry-O-Vac packaged gelatin (6% gelatin, 1% sodium chloride) model 5.5 in. in diameter and 9.0 in. long which froze at approximately the

TABLE 1

Agitation rates used in tests

Agitation rate		A	B	C	D
Stirrer characteristics	Speed, r.p.m.	210	1200	1320	1650
	Propeller diameter, in.	2	2	3.25	5
	Number of blades	3	3	4	3
	Pitch, in.	2.5	2.5	4	4.5
Apparent type of flow in bulk of liquid at —20° F.	Methanol (50% vol.)	streamline	intermediate	turbulent	turbulent
	Calcium chloride (29% wt.)	streamline	intermediate	turbulent	turbulent
	Ethylene glycol (52% vol.)	streamline	streamline	intermediate	intermediate
	Propylene glycol (56% vol.)	streamline	streamline	streamline	streamline
	Glycerol (66% vol.)	streamline	streamline	streamline	streamline

TABLE 2

Physical properties of liquids used in tests

Liquid (Aqueous solutions)	Freezing point, °F.	Density, lb./ft.³ at −20° F.	Specific heat, B.t.u./(lb) (°F.) at −20° F.	Thermal conductivity, B.t.u./(ft.) (hr.) (°F.) at −20° F.	Viscosity, centipoise at −40° F.	Viscosity, centipoise at −20° F.	Viscosity, centipoise at 0° F.	Reference
Methanol (50% vol.)	−42	58.0	0.80	0.23	30[1]	16[1]	8[1]	5
Calcium chloride (29% wt.)	−56	80.6	0.64	0.28	44	21	12	1
Ethylene glycol (52% vol.)	−38	68.4	0.72	0.23	120	50	25	2
Propylene glycol (56% vol.)	−42	66.8	0.78	0.21	850	240	100	2
Glycerol (66% vol.)	−40	75.3	0.56	0.20	2100	980	362	9

[1] Experimentally determined values.

same rate as a 5 lb. eviscerated vacuum packaged chicken, under comparable conditions. (Freezing times at various depths in the model at mid-length and in the breast muscle of the chicken were compared.) A model, 8 in. in diameter, comparable to a 15 lb. turkey, was used to determine the effect of size on freezing rate. The models were constructed on wooden forms consisting of suitably spaced discs on a central core to maintain their shape and hold in position the thermocouples used for temperature measurement. Thermocouples were located under the packaging film and at depths of 0.5, 1.0, and 1.5 in.

Freezing times quoted are the times for the temperature to fall from 32 to 25° F.

Heat transfer coefficients were calculated from freezing times using Plank's equation for the partial freezing time of a cylinder *(11)*:

$$t = \frac{L}{2\theta}\left[(r_o^2 - r^2)\left(\frac{1}{Ur_o} + \frac{1}{2k}\right) - \frac{r^2}{k}\ln\frac{r_o}{r}\right] \quad (1)$$

θ = difference between liquid temperature and freezing point of material to be frozen, ° F.
r_o = radius of cylinder, ft.
r = radius of freezing zone, ft.
t = time required to freeze to radius r, hr.
L = volumetric latent heat, B.t.u./cu. ft.
k = thermal conductivity of frozen material, B.t.u./(ft.) (hr.) (° F.)
U = heat transfer coefficient from frozen material to bulk of liquid, B.t.u./(sq. ft.) (hr.) (° F.)

Latent heat and thermal conductivity of the gelatin at the required temperatures were calculated from the amount of water frozen at these temperatures *(4, 7, 8)*. The amount of water frozen was computed from data on the amount of water bound to gelatin in the presence of salt *(10)* and from data on equilibrium salt solutions *(1)*. The thermal conductivity at 25° F. and the change in enthalpy between 32° F. and 10° F. (rather than between 32° F. and 25° F.) were used in Plank's equation, since these values gave the least variation between heat transfer coefficients calculated from freezing times at various depths during any one experiment. A correction (based on the freezing times for a model with an additional layer of packaging film) was made to allow for the thermal resistance of the Cry-O-Vac packaging material.

RESULTS AND DISCUSSION

Liquid type, agitation rate and temperature. Freezing times at a depth of 0.5 in. varied with agitation rate (lowest to highest) by a factor of approximately 2 for each of the 5 liquids tested, while the maximum variation between liquids at any one rate of agitation was slightly greater than 2 (Table 3, Figure 1). Freezing

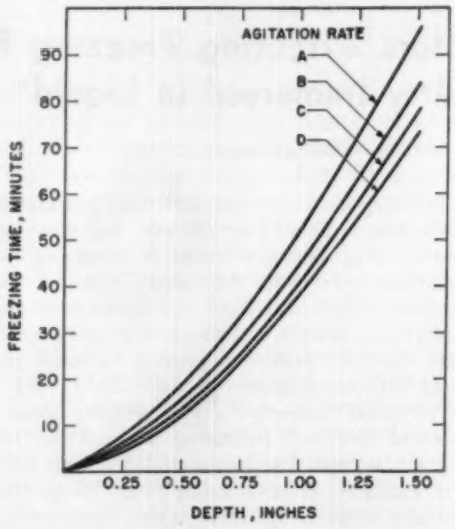

Figure 1. Relation between freezing time and depth in the small model at several rates of agitation. (Freezing in calcium chloride solution at −20° F., initial temperature of model 32° F. Rates of agitation defined in Table 1.)

times in the different liquids increased in the order of liquid viscosity except for the calcium chloride solution. This exception is due to the high density and large thermal conductivity of the calcium chloride solution

TABLE 3

Effect of liquid type, temperature and agitation rate on freezing times (times in minutes, small model)

Liquid	Liquid temperature °F.	Agitation rate (Table 1)							
		A		B		C		D	
		Depth, in.							
		0.5	1.5	0.5	1.5	0.5	1.5	0.5	1.5
Methanol (50% vol.)	−20	22	100	17	85	14	81	13	75
Calcium chloride (29% wt.)	0			30	146				
	−20	18	95	15	83	13	77	12	73
	−40			13	62				
Ethylene glycol (52% vol.)	−20	24	110	18	90	15	83	14	81
Propylene glycol (56% vol.)	−20	29	119	19	95	15	82	14	79
Glycerol (66% vol.)	0			48	184				
	−20	40	141	30	117	23	100	20	98

compared to the methanol solution [see Equation (2) following]. The effect of a given change in agitation on freezing time also increased with viscosity.

Effects of changes in viscosity and agitation on freezing time decreased with increasing depth in the model. Since the increasing depth of frozen material increases the thermal resistance between the freezing zone and bulk of the liquid, a given change in the thermal resistance of the liquid film represents a smaller proportion of the total thermal resistance as the depth increases.

Spraying the models with liquid at 30 p.s.i. pressure gave freezing times comparable to those obtained by immersion at the highest rate of agitation. With calcium chloride solution at —20° F. for example, freezing times at depths of 0.5 and 1.5 in. were 10 and 70 minutes, respectively, in liquid spray, compared to 12 and 73 minutes for immersion freezing.

Freezing times in liquid at 0, —20, and —40° F. were approximately inversely proportional to the difference between liquid temperature and initial freezing point of the material (Figure 2). This is in agreement with Plank's equations *(11, 12)* but contrary to the conclusions of Stiles *(13)*. Since Stiles froze gelatin cylinders in unagitated liquid, the rate of heat transfer may have been dependent on free convection which would vary with liquid temperature.

Size, initial temperature and packaging of model. Freezing times in the large model were greater than those in the small one, the difference decreasing with increasing depth in the model and increasing rate of agitation. Freezing times at a depth of 0.5 in. in the large model were 20% greater at the highest rate of agitation and 45% greater at the lowest agitation rate, than the respective values for the small models. Corresponding values at a depth of 1.5 in. were 7% and 15%. Plank's equation indicates that the differences in freezing time for increasing sizes of model increase rather than decrease with increasing agitation and that these differences should not vary appreciably with depth in the model. The disparity between measured results and those given by Plank's equation may have been due to the limited dimensions of the freezing tank, since its effective diameter (inside the cooling coil) was only slightly more than double the diameter of the large model. It should be noted that the assumption of constant latent heat and thermal conductivity for the material being frozen does not significantly affect the validity of the comparisons which have been made.

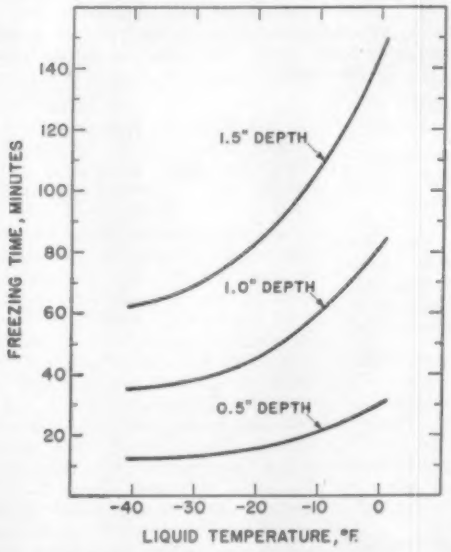

Figure 2. Relation between freezing time and liquid temperature for various depths in small model. (Freezing in calcium chloride solution, initial temperature of model 32° F., agitation rate "B" defined in Table 1.)

Increasing initial temperature of the model from 32° F. to 80° F. increased the time for the temperature to fall to 25° F. (cooling plus freezing) by a factor of 1.4 to 1.5, but freezing times (32–25° F.) decreased by as much as a factor of 3.5. This is in agreement with reports *(3, 7)* stating that freezing time is maximum when the temperature of the material being frozen is initially at its freezing point. The steep temperature gradient in material initially at a high temperature causes the freezing zone to be thin. This thin freezing zone moves inward more slowly than in initially cooler material however, because of the larger amount of sensible heat present above the freezing point. Any point in the sample of material at a high initial temperature will therefore pass rapidly through the freezing range but the cooling plus freezing time for the sample will be longer than if the sample were initially at its freezing point.

Calculations based on the results indicate that a single thickness of Cry-O-Vac packaging material increased freezing times by 14% and 5% at depths of 0.5 and 1.5 in., respectively, at the highest agitation rate. Corresponding values at the lowest rate were 6% and 4%.

Heat transfer coefficients. Heat transfer coefficients increased with increasing agitation rate by a factor of 3 to 4, depending on the particular liquid (Table 4). The variation between liquids depended on agitation rate, ranging from a factor of 3 at the lowest rate of agitation to a factor of 5 at the highest agitation rate. The effect of agitation was maximum in liquids in which turbulence was produced.

Effects of the physical properties of the refrigerant solution on heat transfer are shown by a rearranged form of the equation given by Uhl for heat transfer in agitated tanks *(14)*:

TABLE 4

Effect of liquid type and agitation rate on liquid film heat transfer coefficients[1]
[Small model, initial temperature 32° F., liquid temperature —20° F. Coefficients given in B.T.U./(sq. ft.) (hr.) (° F.)]

Liquid	Agitation rate (Table 1)			
	A	B	C	D
Methanol (50% vol.)	30	55	76	122
Calcium chloride (29% wt.)	39	63	106	167
Ethylene glycol (52% vol.)	24	43	66	80
Propylene glycol (50% vol.)	19	36	64	82
Glycerol (66% vol.)	13	19	29	33

[1] Calculated from equation (1) in text, using measured freezing times.

$$h = Ck_l^{2/3}\rho^{2/3}\left(\frac{c_p}{\mu}\right)^{1/3}\left(\frac{\mu}{\mu_f}\right)^{0.24} \quad (2)$$

h = heat transfer coefficient
k_l = thermal conductivity of liquid
ρ = density of liquid
c_p = specific heat at constant pressure
μ = viscosity of liquid at bulk temperature
μ_f = viscosity of liquid at surface film temperature
C = factor depending on dimensions and agitation

Heat transfer coefficients estimated from this equation are in general agreement with those of Table 4. These coefficients depended mainly on the viscosities of the solutions, as did freezing times (Table 3).

SUMMARY

Immersion freezing times of gelatin models with thermal properties similar to those of poultry varied widely with kind of liquid and agitation rate. Freezing times in each of the 5 liquids tested varied by a factor of 1.5 to 2.0 with agitation rate, while the maximum variation between liquids at a given agitation rate was slightly greater than a factor of two. Freezing times, as well as the effect of agitation on freezing time depended mainly on viscosity and were maximum in glycerol and minimum in calcium chloride. The effect of agitation on freezing time decreased with depth in the model. Spraying the liquid on the models was as effective in reducing freezing times as the highest rate of agitation used.

Freezing times were approximately inversely proportional to the difference between liquid temperature and freezing point of the material.

Cry-O-Vac packaging material increased freezing times by 4–14%, depending on rate of freezing and depth.

Size of the models affected freezing times markedly, the magnitude of the effect depending on depth in the model and agitation rate.

Raising the initial temperature of the models from 32° F. to 80° F. increased the total immersion time by 40–50% but decreased the freezing time (32–25° F.) to about one third.

Heat transfer coefficients, calculated with one of Plank's equations using the measured freezing times, varied more widely than the freezing times, although they depended on the same factors.

Acknowledgment

The authors wish to thank Mr. G. W. Daechsel for technical assistance during this investigation.

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SELECTED ABSTRACTS

(Continued from page 20)

The results obtained in typing over 250 newly isolated *Salmonella* strains with wide spectrum bacteriophages exhibit a pronounced failure to conform to any schema of *Salmonella* species susceptibilities based on O antigens possessed by phage parent strains. The consistent occurrence of cross reactions among these phages is discussed and illustrated.

Anaerobic digestion of algae.

GOLUEKE, C. G., OSWALD, W. J., AND GOTAAS, H. B. (Dept. of Eng., Univ. of California, Berkeley). *Appl. Microbiol., 5,* 47–55 (1957).

A comparison was made of the value of raw sewage sludge and of green algae as sources of nutrient in anaerobic digestion. Additional studies involved a detn. of the effect of temp., alum in the algal feed, detention period, and loading on digester performance.

Induction of Staphylococcal penicillinase.

GERONIMUS, L. H., AND COHEN, S. (Harvard Med. Sch., Boston, Mass.). *J. Bacteriol., 73,* 28–34 (1957).

Thirteen strains of penicillin-resistant coagulase positive staphylococci from clinical sources demonstrated increased penicillinase activity when shaken with penicillin. Under the same conditions seven penicillin sensitive strains showed no penicillinase activity. Penicillinase activity of the routine test strain increased fifteen-fold under conditions precluding significant cellular multiplication. The increase in penicillinase activity was most rapid and pronounced in a complex medium in the presence of air.

Mechanism of action of penicillin.

PEDERBERG, J. (Univ. of Wisconsin, Madison). *J. Bacteriol., 73,* 144 (1957).

There has been a concordance by many workers on the development of protoplasts of L-forms of bacteria. These observations support the argument that penicillin inhibits cell-wall synthesis, and thereby provokes osmotic fragility in the excoriated bacteria.

Growth of micrococci in cooked ham.

MCDIVITT, M. E., AND HUSSEMANN, D. L. (Sch. of Home Economics, Univ. of Wisconsin, Madison). *J. Am. Dietet. Assoc., 33,* 238–42 (1957).

Micrococci predominated in the bacteria present in the uncooked, boneless rolled hams examd. in this study. Some of these organisms survived recommended cooking temps. Growth curves are presented for an enterotoxigenic strain of micrococci on cooked ham held at 2 temps. Rapid multiplication occurred at room temp. (30° C.) between 3 and 18 hrs. Such samples gave no indications of their unfitness for food. No appreciable growth was observed at refrigerator temp. (4° C.). It would seem that conditions frequently encountered in home and institution prepn. of ham are favorable to bacterial growth and present a potential health hazard.

NUTRITION

Amino acid requirements of adult man.

Nutrition Revs., 14, 232–8 (1956).

A discussion of the tentative minimal daily requirements of amino acids as detd. by W. C. Rose et al., includes a composite table of proposed tentative min. and safe intake levels of amino acids.

Theoretical estimates of the protein requirements of children.

HEGSTED, D. M. (Harvard Sch. of Public Health, Boston, Mass.). *J. Am. Dietet. Assoc., 33,* 225–31 (1957).

A calcn. of the minimal protein needs of infants and children emphasizes the relatively small amt. of protein deposited per day as tissue relative to the maintenance requirement and suggests that the total protein requirement may be considerably below that usually fed or recommended. It would appear that the protein needs might easily be met by various vegetable mixts. suitably prepd. The data suggest that the total cal. intake deserves more attention in the soln. of kwashiorkor and that the role of proteins may have been overemphasized.

Pantothenic acid requirement of the growing and adult rat.

BARBORIAK, J. J., KREHL, W. A., AND COWGILL, G. R. (Yale Univ. Sch. of Med., New Haven, Conn.). *J. Nutrition, 61,* 13–21 (1957).

It is believed that the optimal level of pantothenic acid needed for acetylation in adult rats lies between 0.8 to 1.0 mg. of Ca pantothenate per 100 g. of diet.

Significance of iron stores in later life.

STEVENS, A. R. (Univ. of Washington Sch. of Med., Seattle). *Geriatrics, 12,* 88–91 (1957).

Iron metabolism in the aged is discussed, with emphasis, on the significance of storage iron as revealed in microscopic examn. of bone marrow aspirate. Iron stores are depleted in Fe-deficiency anemia, and are increased in other forms of anemia. Iron therapy is never indicated when Fe stores are normal or increased. Especially in elderly people, Fe-deficiency anemia signifies that blood loss has occurred, and the diagnosis carries with it the obligation to find the source of bleeding.

Copper—a growth promotant?

Nutrition Revs., 14, 238–40 (1956).

Addition of $CuSO_4$ to basal rations fed to hogs has given significant wt. gains over control diets under "farm conditions." Action and results are comparable to growth-promoting effects resulting from addn. of antibiotics, arsonic acids and certain sulfonamides.

Nutritional requirements and food fortification.

GRIFFITH, W. *Chemistry & Industry* (1957), 7–8.

The available evidence gives no support to the contention that fluoridation at 1 p.p.m. represents any hazard to human health.

Estimation of atherogenic index and lipoprotein distribution in men.

NICHOLS, A. V., LINDGREN, F. T., AND GOFMAN, J. W. (Univ. of California, Berkeley). *Geriatrics, 12,* 130–40 (1957).

The lipoprotein atherogenic index can be estd. from a gravimetric detn. on a serum total lipid ext. This finding provides an excellent tool in segregating individuals with elevated values of atherogenic index. In comparison, the serum total cholesterol concn. is found to be less efficient in estn. of the atherogenic index.

Nutritional studies of rats on diets containing high levels of partial ester emulsifiers. III. Clinical and metabolic observations.

OSER, B. L., AND OSER, M. (Food Research Labs., Inc., Long Island City, N. Y.). *J. Nutrition, 61,* 149–66 (1957).

The external appearance and behavior of the rats at all levels of partial ester emulsifier were quite normal throughout the two-year feeding test, except for those whose diarrheal condition resulted in inflammation and unthrifty appearance around the anal region. No evidence of anemia, cachexia, or of abnormal neurological behavior was seen in any of the animals, particularly nothing to indicate the existence of any of the recognized nutritional deficiencies. A tendency toward an increase in blood sugar level was noted as the rats reached old age but the values were nevertheless within normal limits. A transient albuminuria was seen in all groups and sporadic positive tests for reducing substances were obtained. But the distribution of these findings among the groups, and the normal blood sugar and on protein N values, suggest that they had no significance attributable to the emulsifiers. Microscopic examn. of urine sediment revealed the presence of occasional oxalate crystals in some of the emulsifier groups but in general fewer were found at the 20% levels than at 10%.

Improving the nutritive value of flour. VII. Supplementing the protein in flour with amino acids.

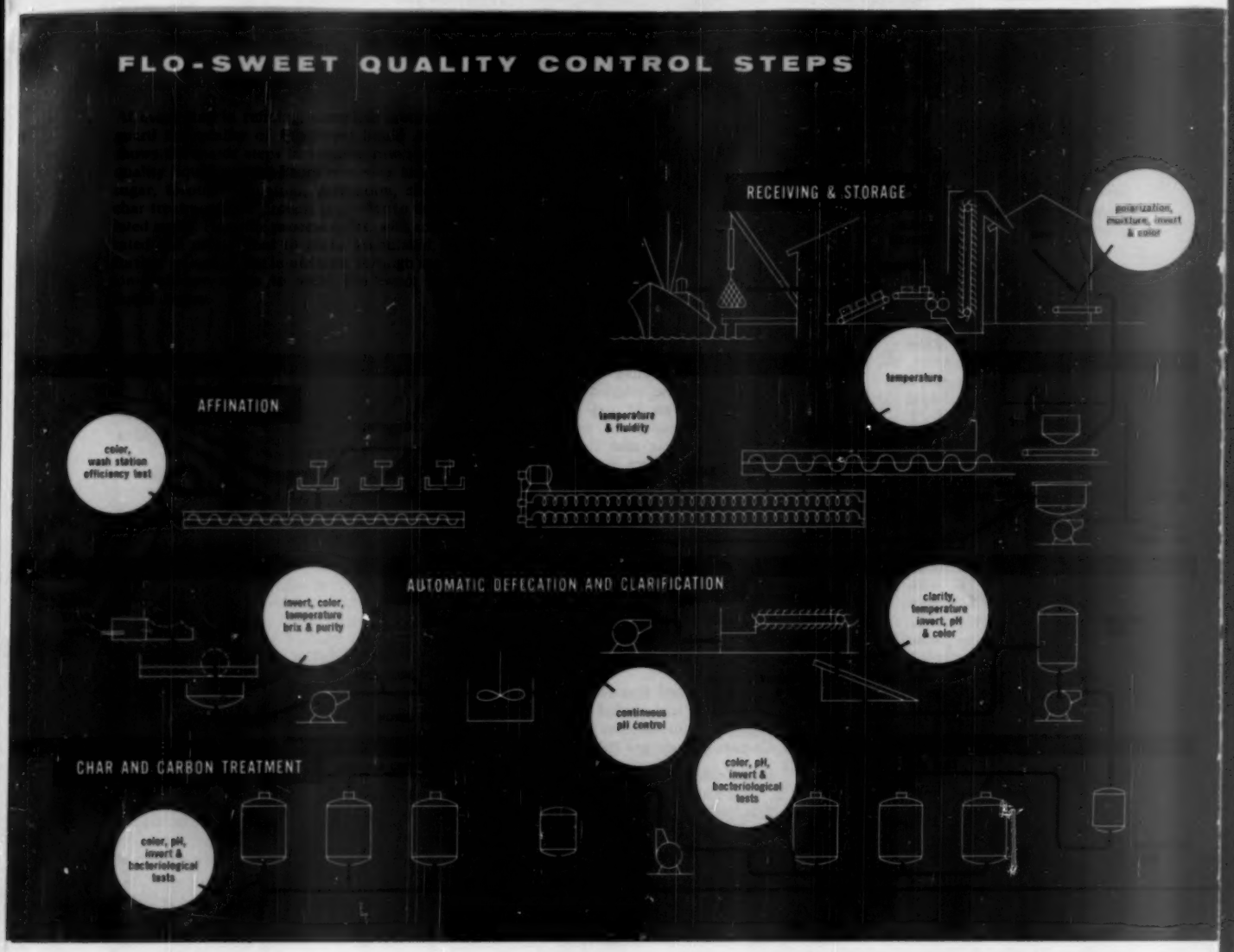
WESTERMAN, B. D., HAYS, B., AND SCHONEWEIS, B. (Kansas Agr. Expt. Sta., Manhattan). *J. Nutrition, 61,* 137–48 (1957).

Experiments were conducted using natural foods to det. the effect of the addn. of lysine, tryptophan, valine and B vitamins to diets high in cereal content and low in meat, milk and eggs on the growth rate, food efficiency, and deposition of B vitamins and fat in the livers of albino rats. Animals on diets contg. 12% meat, milk and eggs with 37% flour had a much better growth rate, food efficiency and healthier appearance than those on diets with 44% flour and no meat. The addn. of lysine was beneficial only when meat was omitted. When the animal protein was removed from the diets, even amino acids, B vitamins and iron were incorporated into the flour, the growth rate and food efficiency were much below those with animal protein in the diet. The results indicate that the quantities of amino acids added to the flour were insufficient to meet the needs of the animals.

Overweight, obesity, and coronary heart disease.

BROZEK, J., AND KEYS, A. (Sch. of Public Health, Univ. of Minnesota,

(Continued on page 380d)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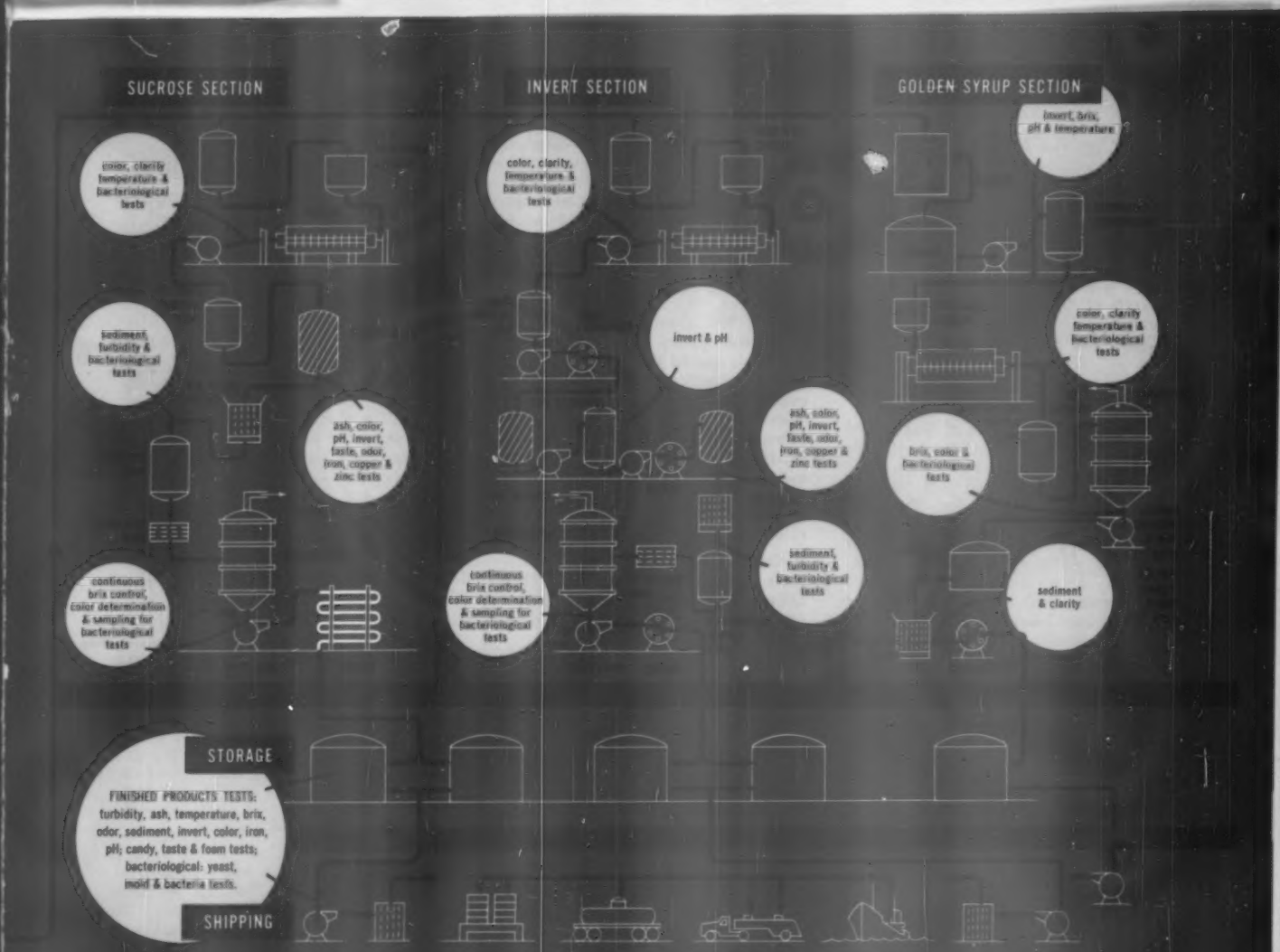
SUCROSE SECTION
INVERT SECTION
GOLDEN SYRUP SECTION
color, clarity, temperature & bacteriological tests
sediment, turbidity & bacteriological tests
ash, color, pH, invert, taste, odor, iron, copper & zinc tests
continuous brix control, color determination & sampling for bacteriological tests
color, clarity, temperature & bacteriological tests
invert & pH
ash, color, pH, invert, taste, odor, iron, copper & zinc tests
continuous brix control, color determination & sampling for bacteriological tests
sediment, turbidity & bacteriological tests
invert, brix, pH & temperature
color, clarity temperature & bacteriological tests
brix, color & bacteriological tests
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(Continued from page 380a)

Minneapolis). *Geriatrics, 12,* 79–87 (1957).

Overweight is frequently regarded as an important factor in the development of coronary heart disease, but available evidence is inconclusive. Additional research is needed to assess more precisely the role of "overweight", "obesity", and the individual difference in skeletal proportions and the distribution of soft tissues.

The obese high school girl.

Nutrition Revs., 14, 229-30 (1956).

A study of two groups of high school girls—28 obese and 28 nonobese—of similar height, age and school grade were compared with regard to phys. maturation, food intake and activity. The obese girls showed an earlier deceleration in height and a tendency toward earlier menarche. (This was regarded as indicative of accelerated development and earlier maturation). The obese group had a significantly lower cal. intake but lower activity indices.

Applying 1953 dietary allowances to U. S. population groups.

LEBOVIT, V., AND STIEBELING, H. K. (Agr. Research Service, U.S.D.A., Washington, D. C.). *J. Am. Dietet. Assoc., 33,* 219–24 (1957).

The article reports how the recommended dietary allowances published by the National Research Council in 1953 have been adapted and used by the USDA in analyses of food supply and dietary survey data that relate to heterogenous population groups as well as in estg. food needs under conditions prevailing in this country.

PHARMACOLOGY AND TOXICOLOGY

Vitmain K and sulfaquinoxaline poisoning in chickens.

JOYNER, J. P., AND DAVIES, S. F. M. *Nutrition Revs., 14,* 240–1 (1956).

Studies indicate that under field conditions two hemorrhage conditions exist in chickens administered sulfaquinoxaline. One is caused by vitamin K deficiency and the other by sulfaquinoxaline toxicity. The method by which sulfaquinoxaline inhibits blood clotting remains unexplained.

Studies on the toxicity of acetoglycerides.

AMBROSE, A. M., AND ROBBINS, D. J. (U. S. Dept. Agr., Albany, Calif.). *J. Am. Pharm. Assoc. Sci. Ed., 45* (5), 282–4 (1956); *Biol. Abstr., 31,* No. 8028 (1957).

No toxic effects were seen in rats receiving single oral doses of 4 g./kg., nor in rats consuming diets contg. 5, 10, or 20% of the acetostearin for 14 weeks, nor in rats on diets contg. up to 4% acetostearin or 1% aceto-olein for 57 weeks. No blood changes or major histopathological visceral damage were seen in rats used for the subacute and chronic toxicity expts. Acetostearin given intravenously, in rabbits, in doses of 80–100 mg./kg. daily for 15 days was nontoxic, had questionable effects on clotting time, and was completely removed from circulating blood within 30 mins. Daily inunction of guinea pigs with 4 ml. of a 30% emulsion for 45 days produced no local or systemic reactions. No sensitization or allergic responses were seen in guinea pigs.

Researches on the constipating action of Satureja hortensis.

VOLLMER, H. *Pharmazie, 8,* 527–30 (1953); *Biol. Abstr., 31,* No. 8020 (1957).

The constipative effect of the herb is apparently due to the tannin content and is plainly manifest in humans at 3.0–4.5% concns. It may also be demonstrated in animals. It also appears after giving infusions or extractives contg. tannic acid. It is lacking after treating the infusion with hide powder, with mucilage, volatile oil, or after exhaustive extraction of the herb with H_2O. A review, with 34 references.

Estimation of the safe dose.

GADDUM, J. H. (Dept. of Pharmacol., Univ. of Edinburgh, Engl.). *Brit. J. Pharmacol., 11,* 156–60 (1956); *Anal. Abstr., 4,* No. 708 (1957).

Small quantities of toxic substances may be present in foods and it is sometimes necessary to decide what is the max. quantity that can be regarded as safe. Statistical methods are described for obtaining from the result of a toxicity test a rough est. of the largest dose which can be considered safe.

PHYSIOLOGY AND MEDICINE

The biology of aging.

WAKERLIN, G. E. (Univ. of Illinois Coll. of Med., Chicago). *J. Am. Med. Assoc., 163,* 950–2 (1957).

Discusses the basic changes in aging. 12 references.

ENGINEERING AND PLANT EQUIPMENT

Structure and performance of filter media.

GRACE, H. P. (E. I. du Pont de Nemours & Co., Wilmington, Del.). *A.I. Ch.E. Journal, 2,* 307–36 (1956).

I. The internal structure of various types of filter media and the nature of fluid flow through them are examd. Various methods of detg. pore dimensions are reviewed. II. Performance data are given for various filter media. The mechanisms of filtration and "clogging" are examd.

Magnetic tape system controls single part production.

Ind. Sci. & Eng., 4 (1), 17–20 (1957).

Digital data is now being used for small-lot and single-part production of finished tools (or parts) directly from control tape.

How far do we go with instrumentation?

CRAWFORD, W. A. (Engineering Dept., E. I. duPont de Nemours & Co., Wilmington, Del.). *Ind. & Eng. Chem., 48* (8), 36A–9A (1956).

How far we go with instrumentation depends on optimum product quality desired, final product cost, and hazards involved in the process.

FOOD AND FOOD TECHNOLOGY

BAKING AND BAKERY RPODUCTS

Effect of gamma irradiation on cake mixes at high and low moisture levels.

BAUMAN, H. E., BAEDER, H., STEIN, J. A., HARREL, C. G., AND LARSEN, R. A. (Pillsbury Mills, Inc., Minneapolis, Minn.). *Food Technol., 11,* 193–6 (1957).

At the levels of irradiation that would be required to cause an appreciable decrease in nos. of bacteria, the color, odor and baking characteristics of cake batters were markedly changed. The most pronounced change was in the gelatinization characteristics of starch.

CEREALS AND GRAINS

Development of starch granules in corn endosperm.

WHISTLER, R. L., AND THORNBURG, W. L. (Purdue Univ., Lafayette, Ind.). *J. Agr. Food Chem., 5,* 203–7 (1957).

With the aid of the electron microscope, starch granules were observed in corn endosperm as early as 4 days after pollination. Granules seemed to originate in amyloplasts, which often rupture as the granules mature. Central cavities are rarely observed in undried granules and lamellae are seen in less than 15% of the granules.

COFFEE AND TEA

Enzymes in tea leaf.

KERGEL, E. L. (Tea Research Inst. of Ceylon). *Coffee & Tea Ind., 80* (3), 69–70 (1957).

The enzyme "tea polyphenol oxidase" oxidizes the tea catechins to form intermediate compds. through condensation thereby giving the red color and good taste to tea. In processing tea, this is done during rolling the leaf at the most active-enzyme temp. of 80–90° F.

FATS AND OILS

Some recently discovered constituents of animal fats.

HARTMAN, L. (Dept. of Scientific and Ind Research, Wellington, New Zealand). *J. Am. Oil Chemists' Soc., 34,* 129–31 (1957).

A series of branched-chain and odd-numbered straight-chain fatty acids was recently isolated from ox, sheep, and butterfat. Substantial amts. of trans-unsatd. acids have been found in the depot fats of ruminants, but none or little in non-ruminants. Mechanisms of the formation of all these constituents based on the activity of rumen bacteria are suggested.

The tocopherols.

BLAIZOT, P., AND MELLIER, M. T. *Oléagineux, 11,* 539–43+ (1956); *Food Sci. Abstr., 29,* No. 189 (1957).

A summary of information on (1) the structure of the tocopherols, (2) the tocopherol contents of various human tissues, and of foods, and fats (ranging

(Continued on page 38)

The Effect of Alternate Freezing and Thawing on the Total Flora of Frozen Vegetables[a]

G. J. Hucker and Elizabeth Russell David
New York State Agricultural Experiment Station, Cornell University, Geneva, New York

(Manuscript received April 1, 1957)

IN THE HANDLING of frozen vegetables from the original storage to the consumer, variations in holding temperature either during transportation, in dispensing cabinets or in the home refrigerator often allows the product to thaw with subsequent freezing.

It could be assumed that an increase in the total flora during alternate freezing and thawing would occur as a result of growth either in the freezing or thawing phase, or that a sudden change in temperature from one phase to the next might disperse bacterial clumps with a corresponding increase in colony count. It has been shown earlier *(1)* that although organisms survive in peas, corn and snap beans when held at —0° F. (—12.7° C.) no growth was apparent. If growth is to occur, it should be found when the frozen vegetables are thawing or thawed. The objective of the current studies is to determine the effect on the total flora of alternate freezing and thawing of commercial frozen vigetables.

Data. The results are based on 5,211 individual samplings from 648 samples of commercial frozen peas, string beans, corn, lima beans and spinach. Ten gram samples of 90 cc. of sterile water were disintegrated one minute in a blendor and plated in replicate using Tryptone-glucose-yeast extract agar. Temperature and time of incubation as used in specific tests are indicated below. In most instances the samples were held for the various observations in the original commercial package.

RATE OF GROWTH IN THAWING FROZEN VEGETABLES

To study the rate of increase of the total flora in frozen vegetables when thawing, commercial 14 oz. samples which had been originally stored at 0° C. (—17.8° F.) were held at 2° C. (35.6° F.), and 7° C. (44.6° F.) and observed at regular intervals. These temperatures approximate conditions in a home refrigerator, 7° C. (44.6° F.) and the approximate minimum temperature, 2° C. (35.6° F.) at which the frozen vegetables become completely thawed. These holding temperatures were attained in the samples at from 2 to 4 hours. The observations were made on 67 samples of frozen corn, 92 samples of frozen peas, and 57 samples each of frozen spinach, string beans and lima beans. No data were available as to the exact period of time which these samples had been hold frozen, prior to these studies. However, from code references, it would be indicated as not less than 2 months or more than 12 months.

The most apparent and significant observation was the general uniformity of the results among samples of the various frozen vegetables. The freezing storage of the samples had so conditioned or changed the total flora that little variation was observed in the samples insofar as growth was concerned when held at 2° C. (35.6° F.) and 7° C. (44.6° F.). At the higher temperature the changes in total flora, Figures 1, 2, 3, 4, and 5, were more evident as the time of holding was increased.

Little or no increase in total flora of the thawing vegetables occurred when held at 2° C. (35.6° F.) up to 70 hours. This was true for the psychrophilic count at 0° C. (32° F.), the mesophilic count at 20° C. (68° F.) and 32° C. (89.6° F.) and the thermophilic count at 45° C. (118° F.). When held for 70 hours at

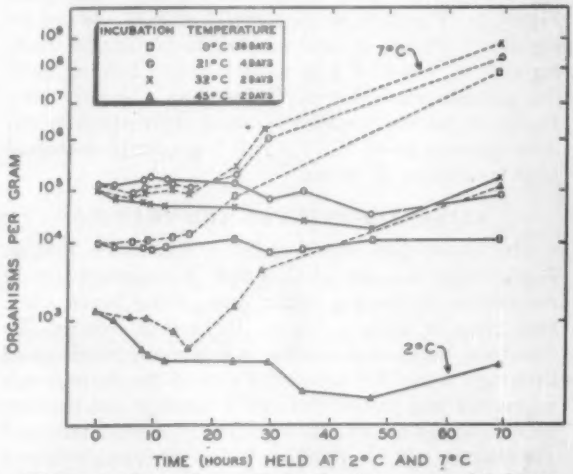

Figure 1. Rate of growth in thawing commercial frozen peas, held at 2° C. and 7° C.

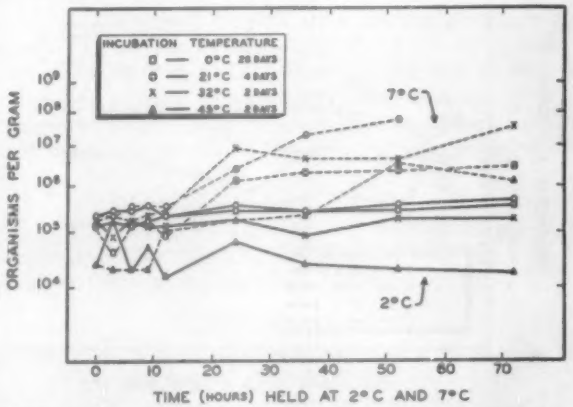

Figure 2. Rate of growth in thawing commercial frozen corn.

[a] Journal Paper No. 1063, New York State Agricultural Experiment Station, Cornell University, February 1957.

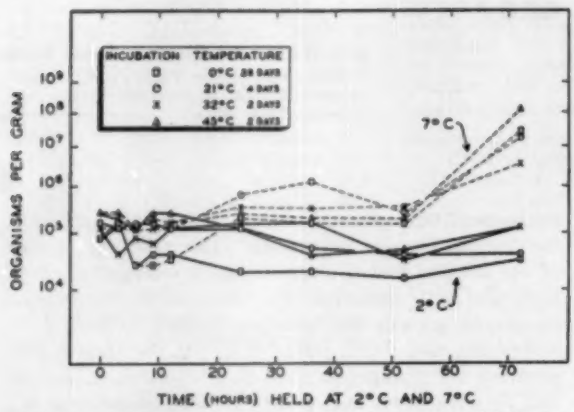

Figure 3. The rate of growth in thawing commercial frozen lima beans.

7° C. (44.6° F.) in most instances the total flora increased. In the case of lima beans, Figure 3, no significant increase was noted until after 50 hours had elapsed. The most rapid increase in total flora when held at 7° C. (44.6° F.) was found in string beans, Figure 4, followed by corn, Figure 2, spinach, Figure 5, and peas, Figure 1. The flora in the samples studied showed no significant change in total number in periods of thawing at 7° C. (44.6° F.) up to 10 hours of holding, with the possible exception of frozen peas. In this case, Figure 1, the thermophilic count as represented by the flora growing at 45° C. (113° F.) gradually decreased after holding for 45 hours.

ALTERNATE FREEZING AND THAWING

The above data would indicate that when held at 7° C. (44.6° F.), or 2° C. (35.6° F.) growth would not initiate in thawing frozen peas, string beans, corn, lima beans or spinach, before 10 hours of holding. To determine the combined effect of alternate freezing and thawing a series of 8 samples of each of the above frozen vegetables was passed through 5 freezing and thawing cycles and the number of organisms present determined (incubation 32° C. (89.6° F.) for 48 hours) at the beginning and end of each phase. In this series, the samples were held for 8 hours at 2° C. (35.6° F.). This period of holding in the thawing phase was adopted as it was less than the minimum time required to initiate growth. Observations were made at the end of 24 hours of the freezing phase. However, in all cases, the samples were not immediately passed through the thawing phase. In no case were samples held frozen longer than one week before the subsequent thawing phase.

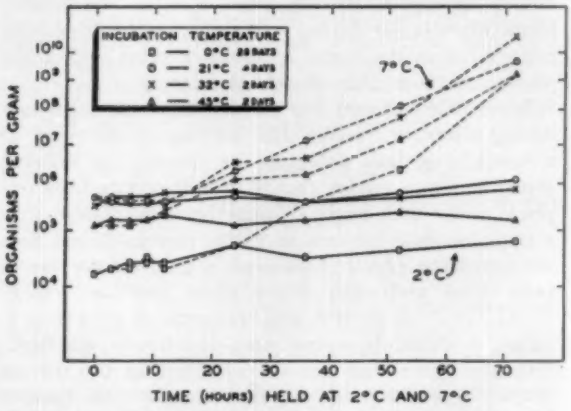

Figure 5. Rate of growth in thawing commercial frozen spinach.

Using either 2° C. (35.6° F.) or 7° C. (44.6° F.) as the thawing temperature with 8 hours' holding before refreezing no significant rise in count was noted in any of the samples when passed through 5 alternate freezing and thawing phases. Results from average typical samples are shown in Figures 6 and 7. Certainly these data indicate that alternate freezing and thawing *per se* does not increase the total flora when the thawing phase does not exceed 10 hours at 2° C. (35.6° F.) or 7° C. (44.6° F.)

To determine if the total initial number of dormant cells present is significant, 6 samples of peas with different population levels were passed through 5 freezing and 8 hour thawing cycles using both 2° C. (35.6° F.) and 7° C. (44.6° F.) No significant relation could be

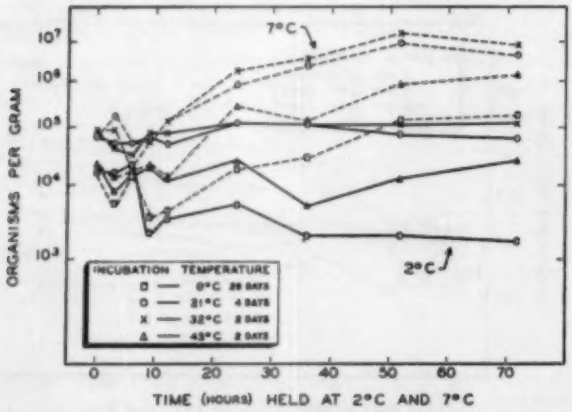

Figure 4. Rate of growth in thawing commercial frozen string beans.

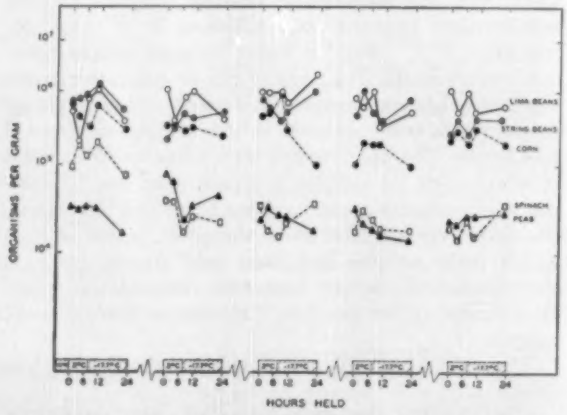

Figure 6. Effect of alternate freezing and thawing (2° C.) on total flora of commercial frozen vegetables.

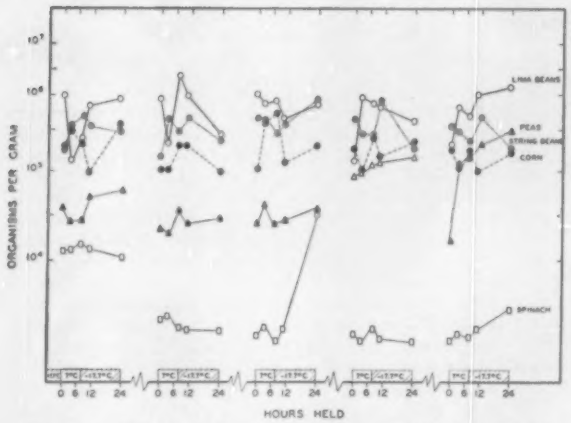

Figure 7. Effect of alternate freezing and thawing (7° C.) on total flora of commercial frozen vegetables.

noted, Figures 8 and 9, between original count and the effect on total count of alternate freezing and thawing.

RELATION OF TEMPERATURE AND HOLDING TIME TO INDICATION OF GROWTH

It has been shown in preliminary results that holding in the thawed phase for sufficient lengths of time initiates growth. When such growth is initiated prior to refreezing, an increased total count results as the alternate freezing and thawing cycles are carried out.

Ten samples each of peas, string beans, spinach, lima beans and corn were held at 32° C. (89.6° F.), 18° C. (64.4° F.), 7° C. (44.6° F.), 5° C. (41° F.), 4.6° C. (40.2° F.), 3.8° C. (38.8° F.), 2.9° C. (35.1° F.) and 2° C. (35.6° E.). The length of time of holding before growth was initiated was determined by hourly examinations. A composite of these results, Figure 10, indicated that alternate freezing and thawing, irrespective of the original dormant count did not increase the total flora provided growth was not initiated in the thawing phase. In demonstrating the maximum time at which the frozen vegetables can be held at thawing tempera-

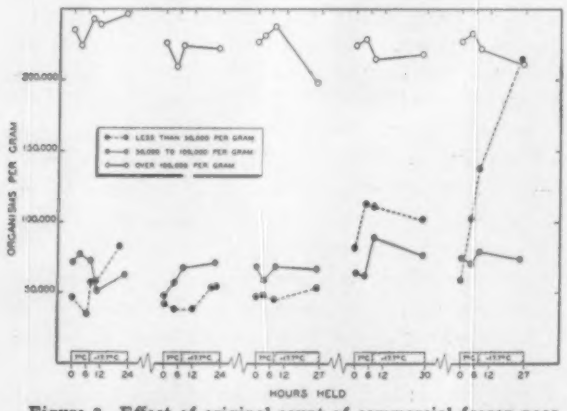

Figure 8. Effect of original count of commercial frozen peas on total flora subsequent to alternate freezing and thawing (7° C.).

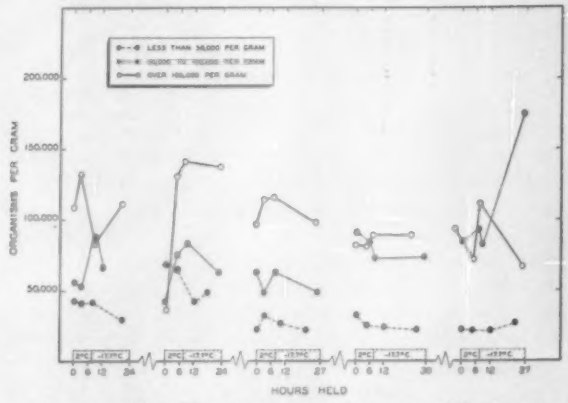

Figure 9. Effect of original count of commercial frozen peas on total flora subsequent to alternate freezing and thawing (2° C.).

ture before growth is initiated, Figure 10 may serve as a guide to controlling or predicting the possible effect of alternate freezing and thawing of frozen vegetables on the total count.

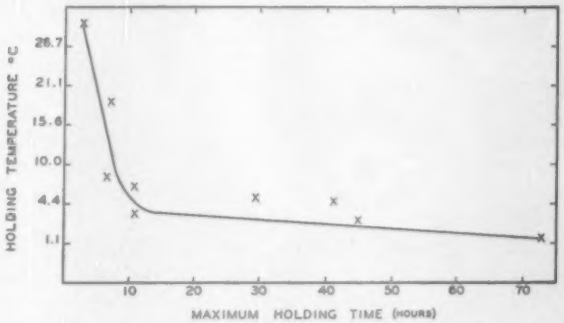

Figure 10. The time at which growth initiates when thawing frozen vegetables are held at various temperatures.

CONCLUSIONS

1. The total bacterial count was not increased during alternate freezing and thawing of frozen peas, corn, string beans, spinach and lima beans provided growth was not initiated in the thawing phase.

2. Frozen vegetables held at a thawing temperature of 2° C. (35.6° F.) did not show an appreciable increase in total flora within 70 hours. Likewise frozen vegetables held at 7° C. (44.6° F.) did not show a significant increase in total count when held up to 10 hours. At 32° C. (89.6° F.) however, growth initiated at 4 hours and at 18° C. (64.4° F.) at approximately 7 hours.

3. The number of bacterial cells in the original sample prior to alternate freezing and thawing is not a significant factor affecting total count as a result of alternate freezing and thawing.

LITERATURE CITED

1. Hucker, G. J. Low temperature organisms in frozen vegetables. *Food Technol.*, 8, 79–82 (1954).

The Heat Content of Bread[a]

H. C. Mannheim,[b] M. P. Steinberg, A. I. Nelson, and T. W. Kendall
Department of Food Technology, University of Illinois, Urbana, Illinois

(Manuscript received March 6, 1957)

THE COMMERCIAL FREEZING OF BREAD and other bakery products has become an increasingly important operation in recent years. Optimum freezing conditions, rates of freezing and defrosting, and factors affecting the quality of the defrosted bread have been studied previously *(4, 5, 6, 7, 8, 11)*. Little information exists, however, on the energy required to freeze or thaw bread; also there is no information on the amount of water frozen at any given temperature. This information is necessary in order to calculate heat content of bread and to evaluate the stability of frozen bread at the given temperature. Short *(10)* showed that at −40° F. it was safe to assume that all the water in foodstuffs is in the ice phase. However, there are no data to show that this is also valid in the specific case of bread. Factors affecting thermal properties of foodstuffs, and previous work done on the determination of enthalpies involved in food freezing were discussed by Mannheim *et al. (2)*.

In this paper the enthalpy of bread is defined as the total heat content of the bread at a given temperature, using an arbitrarily chosen low temperature (here −50° F.) as the point of zero enthalpy or heat content. Sensible heat is energy (calories or Btu) that must be added or removed in order for bread solids, water or ice to undergo a change in temperature. Specific heat is the change in sensible heat per degree of temperature change per unit weight.

In the freezing range the moisture content of bread may go through a change of state. In this case a relatively large amount of energy known as latent heat of fusion must be removed in order to change liquid water to ice without any change of temperature. Distilled water solidifies completely at 32° F. The water in a food contains dissolved solids so that the temperature of freezing is continuously reduced below 32° F. as solidification progresses.

Previous results obtained in this laboratory *(2)* showed that the energy involved in freezing or thawing a food is the same. Therefore, the heat required to thaw bread was measured and used to calculate the heat content of the bread.

MATERIALS AND METHODS

Materials. A Dewar flask calorimeter described by Mannheim *et al. (2)* was used. This calorimeter was built for the purpose of determining enthalpies involved in food freezing, and comparing the observations with published data.

In order to obtain absolute results, such as specific heat and percent water frozen at a given temperature, the apparatus was modified as reported by Mannheim *et al. (3)*. These modifications increased the accuracy of the data obtained.

The heat exchange medium in the calorimeter was 13 kg. distilled water. All temperature measurements were made with copper-constantan thermocouples using a L & N K-2 potentiometer. A 100 ohm resistance heater in the Dewar flask was connected to a Sangamo Electric Co. (Springfield, Illinois) Type J-5 Test Meter. The water medium in the calorimeter flask was stirred constantly to ensure good heat distribution and provide constant environment. Breads used in these experiments were purchased from the regular production runs of the local branch of a national bakery chain. A vacuum oven moisture determination was made on each batch. The bread was stuffed to capacity into No. 1 plain tin cans. The cans were sealed and two thermocouples were introduced through a 1/8 in. hole in the lid as described previously *(2)*. Both white and whole wheat bread were used.

Several cans were filled with 200 ml. double distilled water and used for calibration and check purposes.

Methods. The bread to be studied was put in the cans and placed at the desired test temperature at least 48 hours before starting the run, to allow for complete equilibration to temperature. The temperatures of +1°, −8°, −20° and −40° C. were attained by utilizing available cold storage facilities. For initial temperatures of −69°, −80°, −100° and −200° C., the cans were placed in chloroform at its point of fusion, dry ice-acetone, ethyl alcohol-liquid nitrogen and liquid nitrogen, respectively.

In order to start a run, the test can cooled to the proper temperature was transferred, in a one-gallon Dewar flask which was also at this same temperature, to the constant temperature room where the calorimeter was installed. Initial temperature of the water medium and can contents were recorded. The test can was then quickly transferred from the one gallon flask to the calorimeter flask. Periodic temperature readings were taken on both the water medium and the can content. The medium temperature was maintained constant by manually adjusting the input of the resistance heater in the flask. Room temperature was kept constant at 74° F. ∓ 1.0° F. to simulate adiabatic conditions. The same method was used with either bread or water in the test can.

RESULTS AND DISCUSSION

Duplicate checks using double distilled water were performed at each test temperature to determine the accuracy of the instruments. Agreement to within 1.5% between measurements and calculated values was regarded as satisfactory evidence that all parts of the apparatus were functioning properly. No measurements were made until this agreement had been reached.

In order to calculate the heat content (enthalpy) of any product at a specific temperature the following information is needed:

(a) Base temperature at which the enthalpy is assumed to be zero
(b) Amount of water and dry solids of the product
(c) Specific heat of the water and dry solids over the range from the base temperature to the specific temperature.
(d) The fraction of water that changes phase from ice to water between the base temperautre and the specific temperature, since only this water fraction should be used to calculate the latent heat of fusion.

[a] This paper reports research undertaken with the financial assistance of The Refrigeration Research Foundation and American Society of Refrigerating Engineers.

[b] Present address: Adir Company Ltd., P.O.B. 5030, Tel-Aviv, Israel.

The moisture content of bread could be obtained, the specific and latent heat of water are known *(1)* and the base temperature could be decided. Although a specific heat for the dry solids of bread was given in the literature *(9)*, there was reason to doubt its accuracy over the range from +80° F. to —40° F. The percent water frozen in bread at any given temperature was unknown. Therefore, it was decided to determine the specific heat of bread above and below 0° C. as the first step.

To determine the specific heat of bread above 0° C., cans of bread stored at 1° C. (34° F.) were put in the calorimeter, and the heat required to warm them to the water medium temperature 24° C. (75° F.) was measured. In order to calculate the specific heat of bread solids, the heat required to warm the water content of the bread and the can was subtracted from the total heat. The residual heat divided by the weight of the bread solids and the difference in temperature gave the specific heat of bread solids over that temperature range. Table 1 gives the results of the determinations.

The percent water frozen in bread was unknown. Therefore, in order to determine the specific heat of bread solids below 0° C. a temperature had to be found at which 100% of the bread moisture is in the ice phase. In order to find such a temperature enthalpy determinations were made at about —195° C., —100° C., —80° C., —70° C., and —40° C.

By subtracting from the total energy exchanged the latent and sensible heat of the bread moisture, the sensible heat required to heat the bread solids to 0° C., and the sensible heat of the can, the apparent sensible heat of dry bread solids below 0° C. was obtained. In order to obtain the specific heat, the sensible heat was divided by the known weight of the bread solids and the temperature range covered.

Results of these determinations are given in Table 2. These data indicate that the average specific heat values calculated when the bread was thawed from —200°, —100°, —80°, and —70° C. are essentially the same. But at —40° C. the apparent specific heat became considerably smaller. From this it was concluded that only at approximately —70° C. is it safe to assume that all the water in the bread is frozen (Table 2). The reason the specific heat values at temperatures above—70° C. are smaller is that at these temperatures part of the water is not frozen and this factor was not taken into account in the calculations.

Having determined the specific heat of all bread components, the freezing point curve for bread should be constructed. For this purpose the energy required to

TABLE 1

Specific heat determination of bread, containing 36.6% moisture, above 0° C.

Initial temp. °C.	Final temp. °C.	Weight of bread, g.	Total heat exchanged Kcal.	Sensible heat of water Kcal.	Sensible heat of can Kcal.	Sensible heat of bread solids Kcal.	Sp. heat of bread solids cal./g./° C.
		G	A	B	C	D = A-B-C	D / G x .634 x Δt
0.94	22.07	207.4	4.013	2.377	0.136	1.500	0.36
1.19	22.18	334.0	4.443	2.566	0.135	1.742	0.39
1.27	22.19	319.5	4.157	2.446	0.134	1.567	0.37
1.26	21.99	312.4	4.013	2.371	0.133	1.509	0.37
							Ave. 0.372

TABLE 2

Specific heat determination of bread, below 0° C.

Initial temp. —° C.	Final temp. ° C.	Total wt. of bread g.	Percent moisture of bread	Total heat exchanged Kcal.	Sensible heat of water Kcal.	Latent heat of water Kcal. assuming all frozen	Sensible heat of can Kcal.	Sensible heat of bread above 0° C. Kcal.	Sensible heat of bread below 0° C. Kcal.	Apparent sp. heat of bread solids below 0° C. cal./g./° C.
				A	B	C	D	E	F = A-B-C-D-E	F / wt. of solids x Δ t
195.1	22.1	297.0	37.0	26.660	10.037	8.756	1.327	1.528	5.012	0.14
195.7	22.2	284.8	37.0	25.507	9.651	8.397	1.298	1.472	4.689	0.13
194.5	21.8	270.1	37.0	24.656	9.087	7.959	1.315	1.373	4.922	0.15
195.4	22.1	297.6	36.1	26.660	9.816	8.556	1.296	1.555	5.437	0.15
187.9	22.2	289.1	36.1	25.083	9.402	8.310	1.275	1.514	4.582	0.13
105.6	22.4	215.4	36.1	16.627	5.353	6.195	0.778	1.140	2.381	0.16
97.5	22.2	287.9	35.6	19.866	6.745	8.166	0.734	1.523	2.698	0.15
109.1	22.4	295.8	35.6	21.787	7.373	8.389	0.798	1.576	3.651	0.18
130.7	22.2	266.7	35.6	21.787	7.194	7.560	0.951	1.412	4.671	0.21
107.4	22.1	293.9	35.6	22.073	7.222	8.333	0.790	1.545	4.183	0.21
80.1	22.4	348.9	36.0	22.927	7.340	10.006	0.657	1.851	3.073	0.17
79.1	22.4	336.4	36.0	22.360	7.027	9.648	0.637	1.784	3.264	0.19
78.2	22.4	321.2	36.0	20.923	6.662	9.210	0.664	1.701	2.686	0.17
79.7	22.3	334.6	36.0	21.643	7.006	9.592	0.671	1.769	2.605	0.15
62.7	23.2	300.6	36.2	18.003	5.749	8.676	0.529	1.647	1.402	0.11
68.4	23.3	313.8	36.2	19.780	6.313	9.058	0.562	1.726	2.121	0.15
69.1	23.4	313.6	36.2	19.637	6.349	9.050	0.564	1.731	1.943	0.14
69.4	23.2	311.3	36.2	19.493	6.291	8.971	0.571	1.707	1.953	0.14
40.7	22.4	292.5	36.0	15.101	4.498	8.389	0.386	1.551	0.277	0.036
41.0	22.4	319.8	36.0	16.340	4.937	9.170	0.409	1.698	0.129	0.015
41.6	22.2	253.4	36.0	13.000	3.919	7.266	0.391	1.331	0.093	0.014
										Ave.[1] 0.157

[1] Average was calculated without the last three runs.

thaw cans with bread from —40°, —20°, and —8° C. was determined. In order to calculate percent moisture frozen, the sensible heat of the bread solids, of the water and of the can was subtracted from the total energy exchanged. The residual energy was the apparent latent heat of the ice. The latent heat of the ice, multiplied by 100 and divided by the weight of water in the sample and the latent heat of fusion per gram gave the percent water frozen. Results of these experiments with white and whole wheat bread are presented in Tables 3 and 4. Figure 1 gives a graphical presentation of these data. The curve was fitted to the points for white bread. This curve also fits the data for whole wheat bread except at the lowest temperatures, and the discrepancy in this range has a negligible effect on a total enthalpy calculation. Therefore, this curve is adequate for use in calculating enthalpies of white and whole wheat bread.

Using Figure 1, an enthalpy chart (Table 5) was constructed which can be used to calculate the refrigeration required to freeze any quantity of bread. A sample calculation used to determine the point at —40° F. in this chart is given below.

Data (For water and can, reference 1)

	Btu/lb./° F.
Specific heat of water above 32° F. (0° C.)	1.00
Specific heat of ice 32° F. to —0.4° F. (—18° C.)	0.50
Specific heat of ice —0.4° to —108.4° F. (—78° C.)	0.46

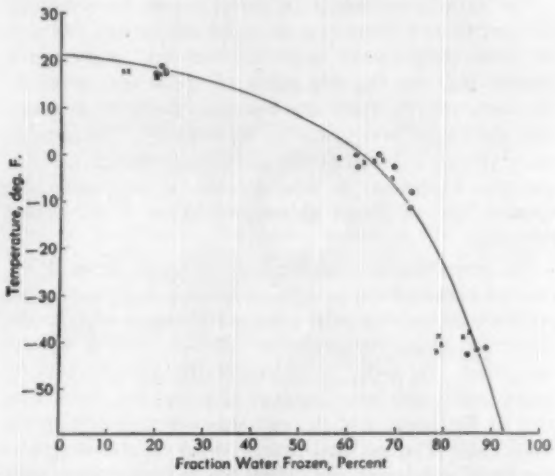

Figure 1. Ice curve for bread (36% moisture content) giving fraction of bread moisture frozen with decrease in temperature. ○ = white bread. × = whole wheat bread.

TABLE 3

Determination of percent water frozen in white bread

Initial temp. —° C.	Initial temp. ° F.	Final temp. ° C.	Wt. of bread g. G	Percent moisture of bread P	Total heat exchanged Kcal. A	Sensible heat of dry bread solids Kcal. B	Sensible heat of water and ice Kcal. C	Sensible heat of can Kcal. D	Apparent latent heat of water Kcal. E = A-B-C-D	Percent of water frozen E x 10000 / P x G x 79.67
40.7	—41.3	22.4	292.5	36.0	15.101	2.770	4.498	0.386	7.654	86.8
41.0	—41.8	22.4	319.8	36.0	16.340	3.041	4.937	0.409	7.953	86.7
41.6	—42.9	22.2	253.4	36.0	12.900	2.410	3.919	0.391	6.180	85.0
19.3	— 2.7	21.9	306.3	37.2	11.610	2.152	3.592	0.270	5.596	61.7
17.9	— 0.2	21.9	310.6	37.2	11.610	2.136	3.557	0.264	5.957	61.4
19.4	— 2.9	21.9	307.5	37.2	12.327	2.132	3.611	0.268	6.326	69.4
17.6	0.3	21.8	307.0	37.2	11.897	2.103	3.502	0.258	6.034	66.3
22.4	— 8.3	22.0	281.6	36.4	11.753	2.102	3.389	0.289	5.973	73.1
24.2	—11.6	22.0	258.0	36.4	10.893	1.970	3.177	0.297	5.449	72.8
8.3	17.1	21.9	319.1	37.2	7.253	1.890	3.092	0.202	2.069	21.9
7.4	18.7	22.0	286.2	36.4	6.307	1.693	2.672	0.188	1.754	21.1
8.1	17.4	21.9	280.8	36.4	6.307	1.681	2.655	0.194	1.777	21.8
8.3	17.1	21.8	288.1	36.4	6.307	1.723	2.726	0.193	1.665	19.9

TABLE 4

Determination of percent water frozen in whole wheat bread

Initial temp. —° C.	Initial temp. ° F.	Final temp. ° C.	Wt. of bread g. G	Percent moisture of bread P	Total heat exchanged Kcal. A	Sensible heat of dry bread solids Kcal. B	Sensible heat of water and ice Kcal. C	Sensible heat of can Kcal. D	Apparent latent heat of water Kcal. E = A-B-C-D	Percent of water frozen E x 10000 / P x G x 79.67
39.5	—39.1	23.4	277.0	36.2	14.006	2.646	4.239	0.413	6.708	84.0
40.2	—40.4	23.2	264.6	36.2	12.986	2.536	3.968	0.407	6.075	79.6
38.9	—38.0	23.2	283.0	36.2	14.333	2.672	4.282	0.414	6.965	85.3
41.2	—42.1	23.3	296.3	36.2	14.620	2.877	4.612	0.416	6.715	78.6
39.3	—38.7	23.4	288.9	36.2	14.133	2.752	4.410	0.380	6.591	79.1
18.3	— 0.9	23.0	264.2	34.5	9.374	1.983	2.920	0.251	4.220	58.1
18.7	— 1.7	23.4	266.3	34.5	9.890	2.031	2.976	0.250	4.633	63.3
18.8	— 1.8	23.3	270.2	34.5	10.176	2.061	3.017	0.249	4.849	65.3
18.2	— 0.7	23.2	261.4	34.5	8.887	1.971	2.908	0.234	3.774	52.5
20.6	— 5.1	23.3	276.7	34.5	10.893	2.158	3.197	0.264	5.274	69.4
18.5	— 1.3	23.2	216.4	34.5	8.313	1.636	2.415	0.251	4.011	67.5
8.5	16.7	23.1	262.8	33.6	5.733	1.727	2.413	0.196	1.397	19.8
8.0	17.6	23.2	292.0	33.6	5.877	1.905	2.671	0.190	1.111	14.2
8.1	17.4	23.1	252.3	33.6	5.017	1.653	2.305	0.187	0.872	13.0
8.3	17.1	23.4	209.4	33.6	4.730	1.390	1.942	0.191	1.207	21.5
8.5	16.7	23.0	278.9	33.6	5.877	1.655	2.549	0.193	1.480	19.8

TABLE 5

Enthalpy of bread containing 36.0% moisture, base temperature —50° F.

Temp. ° F.	Fraction water frozen, percent (Figure 1)	Latent heat of water increment Btu/lb.	Sensible heat of water increment Btu/lb.	Sensible heat of bread solids increment Btu/lb.	Enthalpy increment Btu/lb.	Total enthalpy, cumulative Btu/lb.
—50	89.8	.....	.....	.....	.....	.....
—45	88.2	0.829	0.828	0.512	2.169	2.169
—40	86.3	0.985	0.828	0.512	2.325	4.494
—35	84.5	0.933	0.828	0.512	2.273	6.767
—30	82.5	1.037	0.828	0.512	2.377	9.144
—25	80.5	1.037	0.828	0.512	2.377	11.521
—20	78.0	1.296	0.828	0.512	2.636	14.157
—15	75.0	1.555	0.828	0.512	2.895	17.052
—10	71.7	1.711	0.828	0.512	3.051	20.103
— 5	67.6	2.125	0.828	0.512	3.465	23.568
0	62.5	2.644	0.828	0.512	3.984	27.552
5	54.7	4.044	0.900	0.512	5.456	33.008
10	45.0	5.028	0.900	0.512	6.440	39.448
15	32.1	6.687	0.900	0.512	8.099	47.547
20	10.0	11.457	0.900	0.512	12.869	60.416
21.2	.....	5.184	0.216	0.123	5.523	65.939
25	.....	.....	0.684	0.389	1.073	67.012
30	.....	.....	0.900	0.512	1.412	68.424
32	.....	.....	0.360	0.204	0.564	68.988
35	.....	.....	1.080	0.710	1.790	70.778
40	.....	.....	1.800	1.184	2.984	73.762
45	.....	.....	1.800	1.184	2.984	76.746
50	.....	.....	1.800	1.184	2.984	79.730
55	.....	.....	1.800	1.184	2.984	82.714
60	.....	.....	1.800	1.184	2.984	85.698
65	.....	.....	1.800	1.184	2.984	88.682
70	.....	.....	1.800	1.184	2.984	91.666
75	.....	.....	1.800	1.184	2.984	94.650

Specific heat of can over entire range.....0.10

Specific heat of bread solids above 32° F....0.37

Specific heat of bread solids below 32° F....0.16

Latent heat of fusion of water.....144 Btu/lb.

1 pound bread containing 36.0% moisture

Assume —50° F. as base temperature where the enthalpy is zero.

By definition enthalpy = Sum of the sensible heats + latent heat.

One pound of bread containing 36.0% moisture has 0.36 lb. moisture and 0.64 lb. dry bread solid. From —50° F. to —40° F. 3.5% water changes phase from ice to liquid water (Figure 1).

The latent heat of water = fraction water that changes phase (from Figure 1) x weight of water in sample x latent heat of fusion per lb. = 0.035 x 0.36 x 144 = 1.814 Btu.

Sensible heat of H_2O = weight of H_2O x specific heat x change in temp. = 0.36 x 0.46 x 10 = 1.656 Btu.

Sensible heat of dry bread solids = weight of solids x specific heat x change in temp. = 0.64 x 0.16 x 10 = 1.024 Btu.

Total Enthalpy at —40° F.....4.494 Btu.

Table 5 gives the enthalpies of bread, using —50° F. as the base temperature and assuming 36% moisture for the bread. These data are plotted in Figure 2. Enthalpy values calculated for 35% and 37% moisture bread are given in Table 6. This table permits corrections to be made for variations in moisture content of bread.

To find the energy required to freeze bread, the enthalpy at the final temperature is subtracted from the enthalpy at the initial temperature and multiplied by the weight of the sample. For example, if 250 lbs. of white bread (36% moisture) are to be frozen from 75° F. to —30° F. the calculation is as follows:

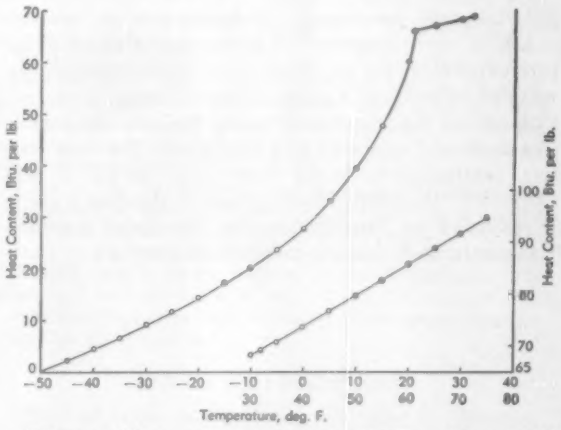

Figure 2. Heat content (enthalpy) of 36% moisture bread above base temperature of —50° F.

Enthalpy at 75° F. = 94.650 Btu/lb.

Enthalpy at —30° F. = 9.144 Btu/lb.

Net change per pound = 85.506 Btu/lb.

Total energy required:

250 x 85.506 = 21376.500 Btu.

SUMMARY

The energy required to be removed from bread in freezing was determined over the temperature range from 75° to —50° F. A Dewar flask calorimeter with water as its heat transfer medium was used. The bread samples of about 200 g. were hermetically sealed in cans.

Two specific heats of bread solids, above and below

TABLE 6

Enthalpy of bread containing 35.0 and 37.0% moisture, base temperature —50° F.

Temp. °F.	35.0% total enthalpy Btu/lb.	37.0% total total enthalpy Btu/lb.
—50	.....	.....
—45	2.131	2.207
—40	4.414	4.574
—35	6.646	6.888
—30	8.979	9.309
—25	11.312	11.730
—20	13.897	14.417
—15	16.734	17.370
—10	19.722	20.483
— 5	23.113	24.022
0	27.008	28.094
5	32.334	33.679
10	38.618	40.276
15	46.515	48.578
20	59.048	61.782
21.2	64.423	67.453
25	65.483	68.539
30	66.903	69.968
32	67.461	70.540
35	69.233	72.349
40	72.185	75.364
45	75.137	78.379
50	78.089	81.394
55	81.041	84.409
60	83.993	87.424
65	86.945	90.439
70	89.897	93.454
75	92.849	96.469

32° F., were determined. Temperatures as low as —328° F. were employed. The fraction of bread moisture existing in the ice phase at any given temperature was determined, and a graph of percent water frozen vs. temperature was constructed using the data obtained in this study and values from a handbook. The heat content (enthalpy) of bread from —50° to 75° F. was calculated. In order to facilitate use of the data a graph of enthalpy vs. temperature for one bread moisture was constructed. Sample calculations are given.

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Time-Temperature Tolerance of Frozen Foods. VI. Retail Packages of Frozen Strawberries

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PRINCIPLES AND OBJECTIVES of the project on time-temperature tolerance of frozen foods have been outlined and discussed by Van Arsdel in the first article in this series *(12)*. Results on frozen peaches have been reported in previous publications *(2, 4)*. This paper deals with the results on commercially packed frozen strawberries obtained during a 5-year period from several packing plants throughout the major strawberry-producing areas of the United States.

MATERIALS AND METHODS

Processing of samples used in these experiments was done in commercial plants with commercial equipment, and the raw material was representative of that which is normally distributed to the retail trade in frozen form. Berries were washed, sorted, sliced, mixed with sugar (4 + 1), packaged (composite cartons and enameled cans), and frozen by one of the following commercial procedures; namely: frozen on trays in air-blast tunnels operated at —10° to —40° F.; case frozen in cold rooms with circulating air at —10° F.; frozen in plate-type freezers maintained at —20° F.; frozen by immersion in calcium chloride brine at a temperature of 0° F. After freezing, all samples were shipped to the laboratory in insulated containers with dry ice which maintained the product temperature below 0° F. at all times. On arrival the samples were placed in a constant-temperature room maintained at —20° F. until the experimental temperature studies were begun.

Each lot of fruit consisted of 120 to 1,400 retail packages and represented a typical commercial pack. During the experiments, 55 different "lots" of fruit representing over 10,000 packages were obtained. These were selected so as to cover the following variables: commercial varieties, growing areas, handling practices, seasonal variation, and freezing procedures.

Temperature schedules. All lots were compared at a steady temperature of 20 ± 1° F. *(3)* and in addition several lots were stored at steady temperatures of 0°, 10°, 15°, 25°, and 30° F. Some lots were held at 0° F. for 3 months and for one year prior to storing at 10° and 20° F. Samples from the same lots were also stored at 10° and 20° F. initially for 6 to 17 days, then cooled to 0° F. and stored at this temperature for 3 months and for one year followed by storage at 10° and 20° F. The purpose of these sequences was to determine whether 0° F. alone or in combination with initial storage at higher temperatures made the samples more susceptible to deteriorative changes during subsequent exposure to higher temperatures.

Finally, many of the samples were exposed to time-temperature patterns calculated to simulate the actual experiences that the samples might encounter during transportation, distribution, and retail cabinet storage. Temperature data for the transportation portion of the patterns were obtained from actual test records supplied by the American Association of Railroads *(1)*. Other simulated transportation patterns were devised in which the maximum temperature gradually reached 10°, 20°, and 30° F. followed by a gradual decline to 0° F. over a 14-day period. Time-temperature patterns were automatically duplicated in refrigerated rooms specifically designed for this purpose *(8)*.

Sufficient samples from each lot were stored at the experimental temperatures to provide 4 to 6 packages for each of 6 to 10 inspection points. Controls for each of the lots undergoing stability tests were maintained at a constant temperature of —20° F. After definite storage intervals the experimental samples were immediately cooled to —20° F. and maintained at this temperature until compared with their respective controls.

Organoleptic evaluation. Most of the organoleptic evaluation of these samples was carried out by the triangle test for both color and flavor. Experimental and control samples were thawed by exposure to circulating air at room temperature for 2 hours and submitted to 5 to 10 trained judges for color evaluation under daylight lamps. Immediately after the color judgments, the same samples were prepared for flavor evaluation under ruby red lamps so as to eliminate color differences. Color and flavor tests were replicated 4 times with 5 judges and 3 times with 10 judges, giving a total of 20 to 30 judgments for each comparison. Where probabilities are expressed for results obtained with the triangle test, they were taken from the Tables of the Binomial Probability Distribution *(11)*. The interpretation of subjective evaluations, obtained in storage experiments such as these, will be discussed more fully in a subsequent paper. In addition to this test, selected samples representing varying degrees of temperature damage were submitted to industry panels. Many of the members of these panels were experts in frozen fruit judging and had had extensive experience in dealing with consumer complaints. Thus, it was possible to obtain an estimate of the degree of quality deterioration which might result in consumer complaint. Finally, some of the samples were submitted to 40 untrained laboratory employees in the form of a paired comparison test.

Analytical. Reduced ascorbic acid was determined on both frozen and thawed samples by the method of Loeffler and Ponting *(6)*. The analytical results represent the average of 2 to 4 packages. On a limited number of samples, total, reduced and dehydroascorbic acid, and 2,3-diketogulonic acid were determined by the method of Roe *et al. (9)*.

Color of the sliced berries was determined by placing the thawed slices in optically matched viewing dishes and measuring the color on a Hunter Color and Color Difference Meter. The instrument was standardized against a standard red kitchen tile (SKC-70) supplied by the National Bureau of Standards. The values used were Rd = 8.6, "a" = 64.4, and "b" = 17.3.

Soluble solids were determined by refractometer and expressed as percent sucrose.

RESULTS AND DISCUSSION

Effect of areas and seasons. In order to determine the relative stability of the different lots of fruit obtained during different seasons and from various areas, all lots were stored at 20° F. and compared with their respective controls maintained at —20° F. Figure 1

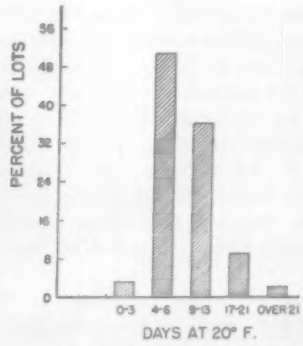

Figure 1. Percentage of total number of lots (55) which became significantly different in flavor from their respective controls after various storage periods at 20° F.

shows that approximately 90% of all the lots tested during this period became significantly different from their controls after 3 to 13 days' storage at 20° F. The majority of these samples changed between 6 and 13 days. Approximately 8% changed between 17 and 21 days and 2% was stable for a longer period. However, the latter 2% was represented by a variety no longer commercially available. Since these data represent different growing areas (Washington, Oregon, California, Louisiana, Tennessee, and Michigan), seasons, varieties, processing procedures and handling practices, it is rather significant that such a large proportion of the lots behaved so similarly with respect to flavor changes at 20° F.

Examined season by season (Figure 2), the data show that approximately 65% of the lots obtained

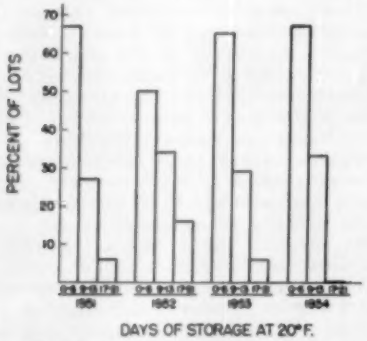

Figure 2. Effect of seasonal variation on time required to develop a significant flavor difference.

during each season changed in flavor within one week except in 1952. During this season about 50% of the lots showed significant flavor changes within the same time interval. During each of the seasons from 1951 to 1954, approximately 30% of the lots changed between 9 and 13 days, leaving only a minor proportion which remained unchanged for over 2 weeks at 20° F. In general, these percentages are fairly constant from season to season and therefore give a good estimate of what can be expected in commercially packed frozen strawberries stored at 20° F. and indicate that seasonal variation is not a major factor affecting storage stability.

Estimate of consumer reaction. It may be well to emphasize that even though most lots of frozen strawberries become just noticeably different in flavor from their controls after as little as 2 weeks at 20° F., this change does not necessarily bear any relation to their acceptability by the general public. To obtain an estimate of consumer reaction, several different samples held at 20° F. for varying times were submitted to quality control experts in the frozen food industry and to groups of industry executives representing warehousing, transportation, distribution, and frozen-food packers.

A summary of results is shown in Table 1. The quality-control experts, who are familiar with quality grading and quality defects leading to consumer complaints, were very definite in their opinions as to when the sample would cause consumer complaint. Only 15%

TABLE 1

Quality grading of frozen strawberries by quality control experts and frozen food industry representatives

Weeks of storage at 20° F.	Percentages of judges indicating cause for consumer complaint		
	Quality control experts [1] %	Industry representatives [2] A %	B %
0	5	4	13
2	10	8	25
4	15	10	46
6	70	25	50
10	....	30	71

[1] Results were obtained with 20 judges on berries packed in composite cartons during the 1953 season.

[2] Results were obtained with 54 judges on the same lot of raw material packed during the 1954 season. Results in Column A were obtained with fruit packed in hermetic containers and those in Column B with fruit packed in metal end composite cartons.

of the graders indicated cause for complaint after 4 weeks at 20° F., but 70% registered this opinion after 6 weeks at the same temperature. This is fairly strong evidence that major quality changes occur between 4 and 6 weeks at 20° F. Thus it would appear that storage beyond 4 weeks at 20° F. would be very unwise. This statement is by no means intended to imply that 4 weeks at 20° F. or the equivalent of this time-temperature experience is satisfactory.

These results are based on evaluation by the largest single group of quality control experts assembled at one time. However, the opinions of smaller groups were obtained during each season (1950–1954) and in every case the majority opinion was that the borderline of acceptability was approached when the samples were stored somewhere between 4 and 6 weeks at 20° F. It is interesting that the consumer-type untrained laboratory panel expressed a significant preference for the control when presented with a control and one stored at 20° F. for 6 weeks in the form of a paired comparison test. Although this 6-week sample was the only one submitted to the consumer-type laboratory panel, it appears that members were in general agreement with the quality control experts in finding important quality differences after 4 to 6 weeks, while highly trained laboratory panels detect differences within one to two weeks at 20° F.

It should be emphasized that these results apply to frozen strawberries of reasonably good original quality. There were instances, however, when the experts graded certain "lots" that were never stored above 0° F. as sufficiently poor to cause consumer complaint. This points up the important fact that poor quality may not always be the direct result of storage at unfavorable temperatures. As a matter of fact, frozen strawberries of high original quality which are subsequently exposed to the equivalent of 3 to 4 weeks at 20° F. may be even better than certain lots which are always maintained below 0° F. However, this paper is primarily concerned with the effect of time and temperature rather than the problem of original quality.

Effect of container. Since most retail frozen strawberries are packed in composite containers (metal ends and paperboard sides), the bulk of the samples used in these experiments were packed in this type of container. However, a relatively small number of commercial sam-

ples were packed in enamelled cans and some of these were subjected to various time-temperature experiences. Of all the variables that were encountered in commercially packed frozen strawberries, container was the most important single variable affecting quality retention during storage at temperatures above 0° F. At 0° F. or lower the effect of container was not readily evident for storage of one year or more. At 20° F., however, it can be readily seen from Table 1 that the hermetic container offered much more protection than the composite against loss in quality. Since the berries packed in the tin and composite containers came from the same "lot" and were processed and frozen in exactly the same manner, the stability differences indicated by the industry panel are strictly due to container. It is of interest that even though the percentage of judges indicating cause for consumer complaint was much less for tin as compared to composite containers, a sharp increase in percentage of complaint judgments occurred between 4 and 6 weeks of storage at 20° F. (10 to 25%). This denotes that quality changes are taking place in the tin can but not nearly to the extent that they occur in composite cartons stored under the same conditions.

Figure 3 shows the results obtained with a trained laboratory panel using the triangle test. Here again the

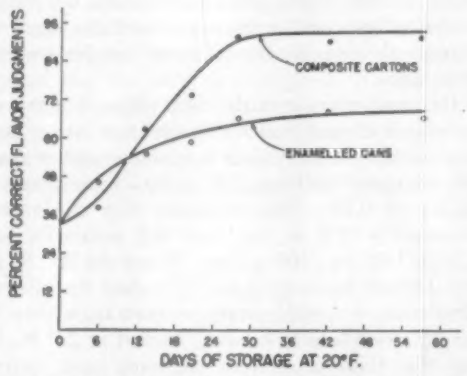

Figure 3. Effect of container on percentage of correct flavor judgments during storage at 20° F.

samples were identical except for container, and it is clear that the rate and extent of flavor change was much greater in the composite carton as compared to the tin container. Even though the first detectable change occurs at approximately the same time, the extent of flavor deterioration as indicated by correct judgments reached a much higher maximum in the composite container.

Another important difference between tin and composite containers becomes apparent when ascorbic acid retention is compared during storage at 20° F. Figure 4 shows a much greater retention of ascorbic acid in tin containers for two ranges of initial ascorbic acid content. These curves indicate a rapid loss of ascorbic acid in the composite container until most of the acid is oxidized. On the other hand the rate of loss in tin containers is more gradual and levels off much sooner than in the composite. It appears that the ascorbic acid

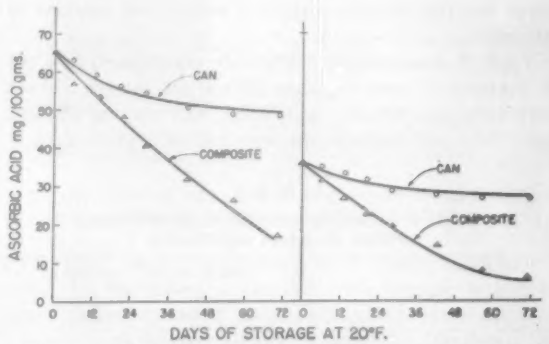

Figure 4. Effect of container on ascorbic acid retention in frozen strawberries of varying original ascorbic acid content.

oxidized in the hermetic containers is limited to the amount of oxygen originally sealed into the container. When this amount of oxygen is used up, little or no additional oxidation takes place. Since the composite carton is not hermetic, the fruit is in constant contact with oxygen supplied by the breathing action of the container, and consequently oxygen does not become a limiting factor. It is probable that this difference in oxygen levels between the 2 containers also accounts for the improved flavor stability in tin cans.

Original ascorbic acid content. One of the most important nutritional constituents in frozen strawberries is ascorbic acid or vitamin C. In certain areas, the concentration of this vitamin is such that a 100-g. portion of 4 + 1 berries supplies well over the minimum daily requirement. In fact, 100-g. portions of over 90% of the lots obtained from the Northwest area (Oregon and Washington) would supply from 1½ to 2 times the minimum daily requirement (30 mg. per day). The distribution of ascorbic acid found in various areas is shown in Figure 5. These data show that under 10% of the lots from the Northwest area contained less than 40 mg./100 g. and over 60% contained 50 or more mg./100 g. These figures indicate that frozen strawberries from this area are an excellent source of vitamin C, provided the temperature is maintained at 0° F. or lower. These values are similar to those reported by Loeffler *(7)*. Berries from other areas are considerably

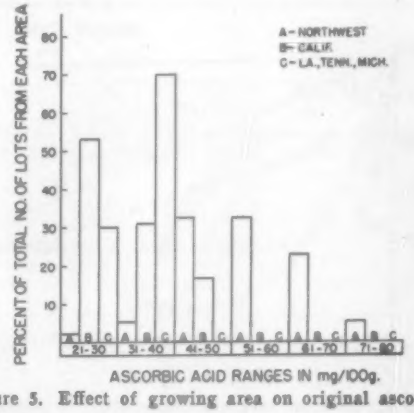

Figure 5. Effect of growing area on original ascorbic acid content.

lower but nevertheless supply a substantial amount of vitamin C.

Table 2 shows that considerable variation may occur in vitamin C content from season to season. These variations are probably associated with varying climatic conditions and cultural practices within a given area.

TABLE 2

Effect of season on variation in ascorbic acid content of frozen strawberries

Packer	Reduced ascorbic acid content (mg./100 g.)			
	1950	1951	1952	1953
A	53	57	53	40
B	43	70	59	63
C	45	59	43	....
D	48	46	38	40
E	....	60	67	60

Effect of various steady temperatures. While properly stored frozen strawberries are generally a good source of ascorbic acid, the curves in Figure 6 indicate that this vitamin is lost rapidly during storage at temperatures above 0° F. Data for both the composite and hermetic containers show little or no loss of ascorbic acid at 0° F. As shown earlier, the loss of ascorbic acid in hermetic containers stored at temperatures above 0° F. appears to be limited by the amount of oxygen sealed in the container. This is borne out by the fact that the curves for all temperatures tend to level off at approximately the same ascorbic acid value.

In the composite cartons, however, the rate of ascorbic acid loss in mg./100 g./day (taken from initial rates) increased logarithmically with increasing temperature. This is shown in Figure 7 for 2 uniform lots of berries packed in different types of composite cartons and with different original ascorbic acid contents. Even though the samples of berries differed in packing season, container type, and original ascorbic acid content, a linear logarithmic relation between relative rate of ascorbic

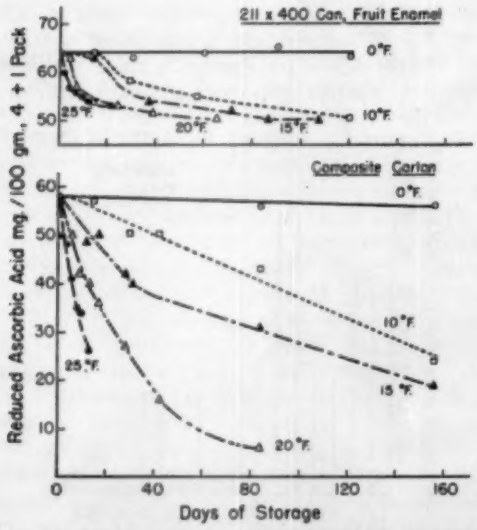

Figure 6. Effect of time and temperature on ascorbic acid changes in frozen strawberries packed in different containers.

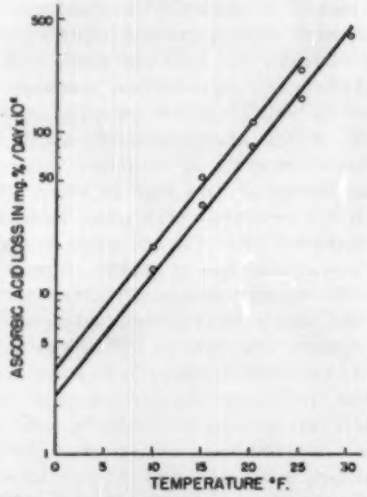

Figure 7. Effect of temperature on relative rate of ascorbic acid oxidation in different lots of berries. The two lots were obtained in different areas, during different seasons, were packed in different types of composite cartons, and had different initial ascorbic acid contents.

acid oxidized and temperature was obtained for both lots. These data indicate that the factors considered may influence the rate at any given temperature, but the relation between rate and temperature remains fairly constant, since the lines for the different samples are essentially parallel.

In this connection it is also interesting that the rates of ascorbic acid oxidation for 36 different lots of strawberries packed in composite containers and stored at 20° F. averaged 0.90 mg./100 g./day with a standard deviation of 0.08. This indicates that the rates of approximately 95% of the "lots" fall within the range of 0.74 to 1.06 mg./100 g./day. From the 20° F. rates for the 2 lots plotted in Figure 7 it is clear that the range of rates covered would encompass even more than 95% of the 36 lots whose rates were studied at 20° F., indicating that these 2 samples represent near extremes with regard to ascorbic acid oxidation. These curves (Figures 6 and 7) show that ascorbic acid in frozen strawberries is extremely sensitive to temperatures above 0° F. and may serve as a good indicator of time-temperature experience. If the ascorbic acid content after freezing is known, the approximate time-temperature experience in terms of steady-temperature storage can be estimated by dividing difference in ascorbic acid content by loss per day for any of the temperatures shown. This will give the approximate equivalent storage time in days for frozen strawberries packed in composite cartons.

It is recognized that in certain cases it may be difficult to ascertain the original ascorbic acid content, and since it has already been demonstrated that ascorbic acid varies according to season and area, reduced ascorbic acid in itself may not give a very accurate picture of time-temperature damage unless the area at least is taken into account.

Figure 8 shows that as ascorbic acid is oxidized during storage at 20° F. a fairly linear increase in 2,3-

diketogulonic acid is obtained. It was hoped that this determination would give an approximation of temperature damage irrespective of original ascorbic acid content. However, Table 3 shows as high as 100% variation in original diketogulonic acid content (6 to 12 mg./100 g.) and the maximum difference could represent approximately 3 weeks of storage at 20° F. Obviously both dehydroascorbic acid and diketogulonic acid may be formed prior to freezing as well as during storage at temperatures above 0° F. Therefore, determination of all 3 compounds may serve as an index of total accumulated quality loss arising both as a result of storage at unfavorable temperatures and prolonged delay prior to and during freezing. This possibility is being investigated and details will be reported later.

Color and flavor. After examination of several different lots it was found that the major color changes in frozen strawberries were represented best by changes in the Hunter "a" value. This value gives an indication of the relative redness of the sample, high values indicating bright red and low values indicating a dull grayish appearance. Figure 9 shows the results obtained with a typical uniform lot of berries packed in composite containers. The decrease in "a" value is essentially linear for all temperatures from 0 to 25° F., and the rate of decrease varies logarithmically with increasing temperature as shown in Figure 10. The rate in terms of change in "a" value per day plotted against temperature on semilogarithmic paper gives a straight line, showing that the rate of change in relative redness varies exponentially with storage temperature.

Subjective evaluation of color and flavor with the triangle test indicated that if the results obtained at various temperatures were compared at the point where

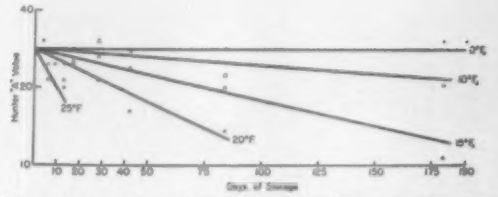

Figure 9. Effect of time and temperature on color changes of frozen strawberries packed in composite cartons.

70 to 80% correct judgments were obtained, these results also varied exponentially with storage temperature. Seventy to 80% correct judgments were used in preference to the conventional probability levels of 0.05 to 0.01 (55 to 60% correct judgments), because a clearer expression of effect of temperature on rate of deterioration was obtained when differences were compared at the higher percentage of correct responses. A more detailed discussion of this point will be presented in a later publication. Furthermore, when time required for 70 to 80% correct judgments is plotted against temperature on a semilogarithmic scale, a straight line is obtained for both color and flavor (Figure 11). It is interesting that in frozen strawberries color and flavor changes occurred at approximately the same time. In some cases flavor changes may occur somewhat sooner than color changes but the difference in time is very small.

Since this same exponential relation has been shown for ascorbic acid loss and Hunter "a" value, the relation-

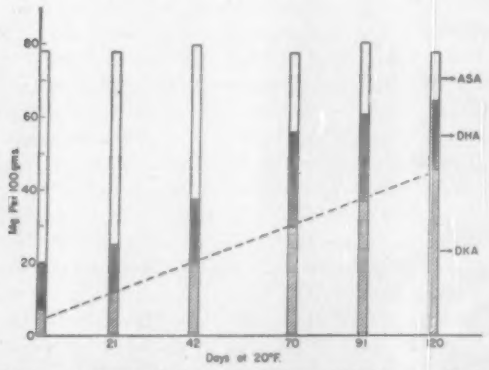

Figure 8. Accumulation of various oxidation products of ascorbic acid during storage at elevated temperatures. ASA = ascorbic acid. DHA = dehydroascorbic acid. DKA = diketogulonic acid.

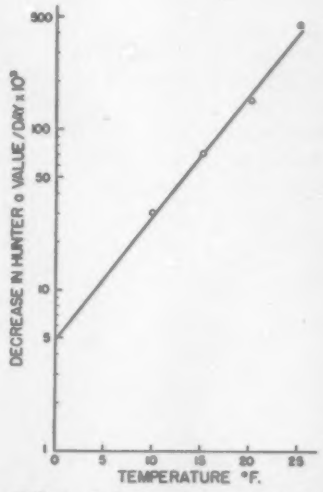

Figure 10. Effect of storage temperature on relative rate of color change as measured by the Hunter Color Difference Meter.

TABLE 3

Variation in amounts of ascorbic acid and its oxidation products in frozen strawberries maintained at a steady temperature of −20° F.

Lot no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	(mg./100 g.)													
Reduced ascorbic acid	29	33	34	35	38	39	43	46	46	53	54	58	60	64
Dehydroascorbic acid	11	6	7	8	7	9	11	9	14	9	16	14	9	11
Diketogulonic acid	11	8	9	6	10	6	8	9	9	11	8	7	12	11
Total as ascorbic acid	51	47	50	49	55	54	62	64	69	73	78	79	81	86

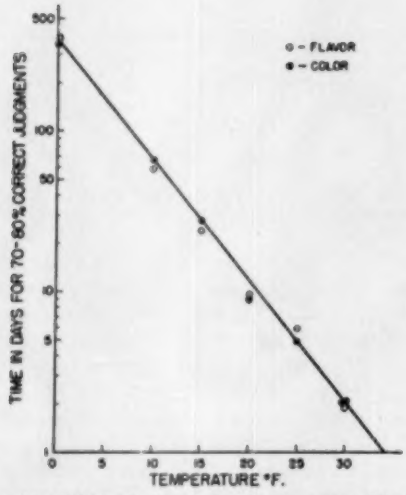

Figure 11. Effect of storage temperature on subjective color and flavor changes as measured by the triangle test.

ship between these values and subjective color and flavor estimations are shown together in Figure 12. The values for Hunter "a" value and ascorbic acid loss are expressed as the reciprocal of the relative rates for comparison with the subjective data. Since the lines are essentially parallel with one another, it is clear that temperature is affecting these values in the same general manner. This demonstrates an excellent correlation between the Hunter "a" value and the subjective estimation of color differences and ascorbic acid loss. Undoubtedly the changes in relative redness measured by the Hunter meter are very similar if not the same changes which enable visual observers to detect color differences in frozen strawberries. The fact that ascorbic acid and flavor are affected by temperature in a similar manner may be a coincidence, since it is unlikely that the same reaction is responsible for color, flavor,

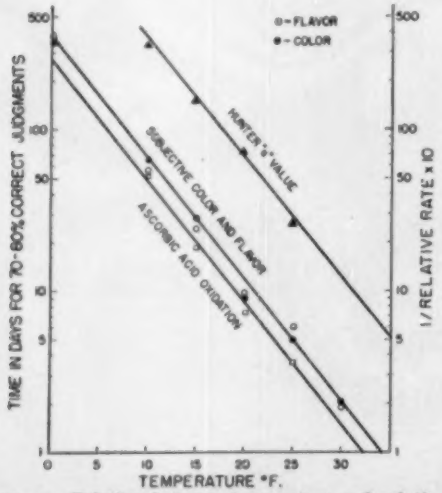

Figure 12. Relation between temperature and relative rates of color, flavor, and ascorbic acid changes in frozen strawberries. Hunter "a" values and ascorbic acid oxidation are expressed as the reciprocal of relative rate x 10.

and ascorbic acid changes. Nevertheless it is apparent that temperature affects the relative rate of the reactions responsible for each of these changes by the same order of magnitude.

Soluble solids distribution. The ratio of soluble solids between drained fruit and sirup indicated no significant change during storage at temperatures of 10° F. or lower. As shown in Figure 13, when the temperature is raised to 20° F. there is a slight increase in solids ratio until an apparent equilibrium value is reached. At 25° F. a very gradual increase in solids ratio occurs, denoting a steady increase in soluble solids of the fruit and decrease in the sirup. Of major interest, however, is the rapid approach to the equilibrium value of 1.0 when the berries are stored at 30° F. At this temperature, equilibrium is attained within 8 days, and

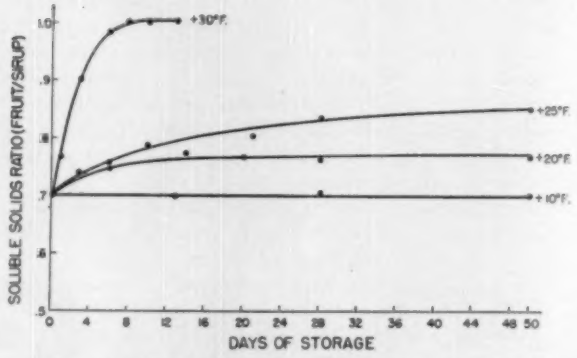

Figure 13. Effect of time and temperature on soluble solids distribution in frozen strawberries.

it is clear that thawing temperatures are necessary for the soluble solids of the fruit to become equal to that in the sirup. At temperatures below the thawing point, an equilibrium value of 1.0 is never reached, and therefore the solids ratio serves as an excellent thawing indicator. Even a solids ratio of 0.9 would indicate thawing for a few days, because at steady temperatures below the thawing point this value would be reached only after very long storage if at all.

Even though marked changes in solids distribution occurred in the thawed samples, no significant drained-weight changes could be demonstrated during storage at temperatures of 0 to 30° F.

Cumulative effect. Data in Table 4 show that approximately 65 to 75% correct flavor judgments were obtained when samples were stored at 20° F. 6 days, regardless of the manner in which this experience was combined with 0° F. storage. If the initial storage at 20° F. for 6 days or at 0° F. for 3 months or a year were to cause a buildup of components or precursors which would subsequently give rise to a much more rapid rate of deterioration during subsequent exposure to unfavorable temperatures, the percentage of correct judgments should have increased markedly.

The fact that no marked increase occurred shows that storage at 0° F. causes little flavor change and that prior storage at 20° F. does not markedly increase susceptibility to deterioration during subsequent storage at

TABLE 4

Effect of various combinations of 0° and 20° F. storage on color and flavor changes in frozen strawberries

Storage conditions	Percentage of correct judgments[1]	
	Color	Flavor
6 days at 20° F.	60	70
6 days at 20° F. followed by 3 months at 0° F.	45	65
3 months at 0° F. followed by 6 days at 20° F.	50	70
6 days at 20° F. followed by 1 year at 0° F.	75	75
1 year at 0° F. followed by 6 days at 20° F.	65	65
12 days at 20° F.	75	85
12 days at 20° F. followed by 1 year at 0° F.	80	85
1 year at 0° F. followed by 12 days at 20° F.	80	80
6 days at 20° F. and 1 year at 0° F. followed by another 6 days at 20° F.	80	85

[1] 60% correct judgments represent a probability level of .01.

0° F. or *vice versa*. Storage at 20° F. for 12 days causes a definite increase in both color and flavor change, and this is borne out by 80 to 85% correct flavor judgments and 75 to 80% correct color judgments. It will be noted that the results are similar regardless of how the 12 days at 20° F. were combined with 0° F. storage. The important damage occurs as a result of storage time at 20° F. rather than the sequence of combinations. These experiments were repeated at 10° F. and an additional experiment was conducted at 15° F., where stability was determined after 0, 6, 12, and 18 months of storage at 0° F. With the 0° F. samples as controls, the time required for significant flavor differences to develop at 15° F. did not vary significantly throughout the 18-month period. This is additional evidence that precursors for increased deteriorative changes are not developed during prolonged storage at 0° F.

The experiments at 10° F. in combination with 0° F. storage revealed nothing but additive changes. Further evidence of the additivity of changes during storage at 0 and 20° F. is shown in Figure 14. Ascorbic acid loss for storage at a steady temperature of 20° F. or for combinations of 0° F. for 3 months and 20° F. generally follows a straight line, indicating little or no loss for storage at 0° F. for 3 months. Combinations of 20° F. and 0° F. for one year also fall on a straight line, but this line is displaced by an amount roughly equal to the loss which occurs at 0° F. for one year and is parallel to the first line. Since the slopes of the lines are similar, it is clear that the rate of loss after one year at 0° F. is roughly equivalent to the rate of 20° F. prior to storage at 0° F. This presents a very clear picture of an additive effect.

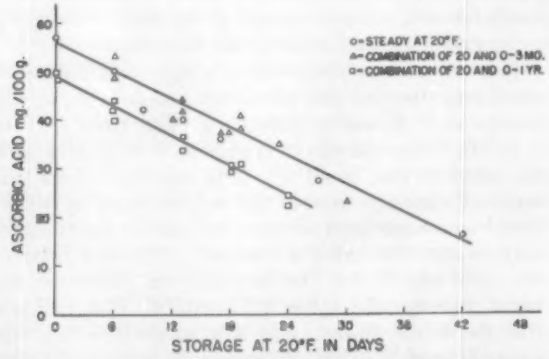

Figure 14. Ascorbic acid changes in frozen strawberries held at 20° F. prior and subsequent to 0° F. storage for 3 months and one year.

Effect of distribution practice. The effect of various distribution patterns (Figures 15 and 16) on flavor changes is shown in Figure 17 and Tables 5 and 6.

TABLE 5

Comparison of various simulated distribution patterns on ascorbic acid and flavor changes in frozen strawberries

Lot No.	1		2[1]		3	
Time temp. pattern[2]	40[5]		53[5]		60[5]	
	A.A.[3]	Flavor[4]	A.A.	Flavor	A.A.	Flavor
R 10	100	33	100	40	100	45
R 20	85	54	94	50	93	58
R 30	33	68	81	55	67	65
RDC 10	98	35	98	35	100	58
RDC 20	80	58	89	61	85	66
RDC 30	0	100	77	91	40	100

[1] Packed in hermetic container.
[2] See Figure 16 for time temperature pattern.
[3] Ascorbic acid retention in percent of original.
[4] Percentage of correct flavor judgments using the triangle test. Fifty-five to sixty percent represents a probability level of .05 to .01.
[5] Original ascorbic acid content mg./100 g.

From these data it is apparent that as long as the maximum temperature does not exceed 10° F., no significant flavor changes occur during a simulated 14-day transportation trip plus simulated retail distribution and cabinet storage for another 13 days. When the maximum temperature is 20° F., each succeeding experience above

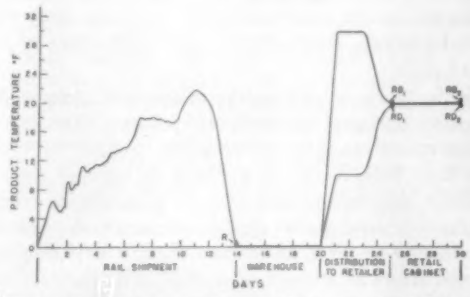

Figure 15. Time-temperature pattern for simulated transportation and distribution.

0° F. causes an increase in percentage of correct judgments, indicating an increasing degree of flavor change. The R-20 to RDC-20 series again demonstrates the additive effect of temperature sequences above 0° F. In this series the 14-day transportation cycle caused changes which were on the borderline of detectability while the complete distribution cycle RDC-20 caused a definitely detectable flavor change. With 30° F. as a maximum temperature, the transportation cycle causes a significant change, and the entire distribution cycle RDC-30 causes a very marked flavor change which was detectable by 90% of the judges.

Table 5 shows a comparison of flavor changes and ascorbic acid retention for these simulated distribution practices. These data show a good correlation between ascorbic acid and flavor retention. It also demonstrates again the superiority of the hermetic container with respect to ascorbic acid retention under severe time-

TABLE 6

Comparison of storage at 20° F. and simulated distribution practice on ascorbic acid retention

Lot no.	Original ascorbic acid content mg./100 g.	Percent ascorbic acid retention							
		Days at 20° F.			Simulated distribution[1]				
		6	13	18	R	RB_3	RB_2	RD_1	RD_2
1	32	81	65	50	75	63	53	67	57
2	46	93	70	50	80	65	46	75	58
3	54	84	65	50	73	55	40	67	56
4	57	82	70	60	81	68	54	72	68
5	60	92	68	60	75	58	48	68	57
6	63	89	64	43	79	65	40	67	60
7	65	88	72	61	79	61	49	77	68
8	70	93	84	60	84	70	60	81	67
9	72	82	63	50	73	64	43	71	65
10	75	92	68	60	75	58	48	68	57

[1] See Figure 15 for time temperature pattern.

temperature conditions. It is also apparent that for short distribution periods of 2 to 4 weeks, the maximum temperature attained was of primary importance. At a maximum temperature of 10° F. no significant damage was encountered; a 20° F. maximum caused definite flavor and ascorbic acid changes and a 30° F. maximum caused severe changes. Table 6 shows percent ascorbic-acid retention for several lots during a simulated distribution pattern which was designed from actual temperature records. This is the same pattern which was described in the report on peaches *(3)*. Comparing the transportation segment of the pattern with steady storage at 20° F., it is apparent that the transportation cycle alone was generally slightly worse than 6 and slightly better than 13 days of storage at 20° F. with respect to ascorbic acid retention. In general the sequence in which the product reaches 30° F. for a few days (RB_2) caused a change which was roughly equivalent to 20° F. for 18 days.

In the work on cumulative effects and simulated distribution patterns, all evidence points to the fact that deteriorative changes are additive. All of the changes that have been found as a result of varying time-temperature sequences could have been predicted from the results obtained with steady temperatures. In other words, any given deteriorative change in frozen strawberries arises as a result of storage at a relatively steady temperature for a given time or as the accumulation of various time-temperature experiences, all of which contribute to the total damage. Where the total distribution time (transportation, retail distribution, and cabinet storage) was in the neighborhood of 3 to 4 weeks, the most important factor affecting total damage was the maximum temperature attained during any of these sequences.

Effect of regular fluctuations. Commercial packs of frozen strawberries were subjected to a large variety

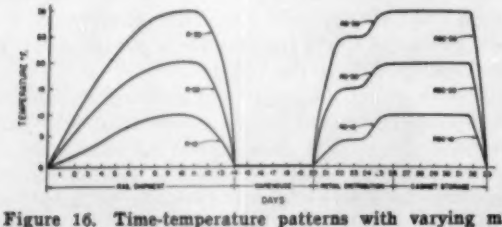

Figure 16. Time-temperature patterns with varying maximum temperatures.

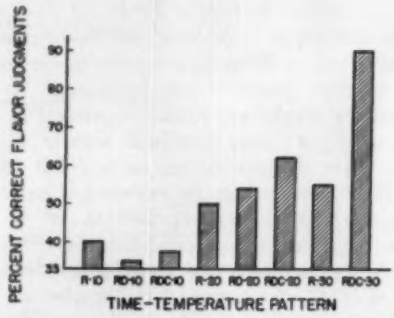

Figure 17. Effect of various simulated distribution practices on the detection of flavor differences between experimental and control samples.

of regular sine wave fluctuations covering the range of −10 to +30° F. The principal object was to determine whether temperature fluctuation *per se* caused significant deteriorative changes over and above those that would be expected on the basis of the mean effective temperature. It has been pointed out that the mean effective temperature in a regularly fluctuating cycle lies somewhere above the mean arithmetic temperature and depends on the temperature coefficient of the particular reaction in question *(10)*.

In view of the large amount of data obtained, it is not possible to present a complete picture of the fluctuation results in this paper. The bulk of the data on fluctuating temperatures will appear in a separate paper and will cover raspberries as well as strawberries. In general, however, no significant flavor differences were found between samples stored at regularly fluctuating cycles and at the arithmetic mean temperature.

The only comparison in which a significant difference was found after one year of storage was between steady storage at 0° F. and a fluctuating cycle from −10 to +10° F. Since the rate of change at 0° F. is very slow compared to that at 10° F., it is readily obvious that eventually enough time in the neighborhood of 10° F. would be accumulated to cause substantial deteriorative changes and thus cause a detectable difference between the cycle and 0° F. The fact that no difference was found between the cycle and −10° F. also indicates that the effect of the cycle was somewhere near the upper limit of +10° F. Wherever the arithmetic means were 10 or 20° F., significant flavor differences could not be detected between cycle (0 to 20 and 10 to 30)

and mean even when the amplitude and frequency of the cycles were varied. These results rather conclusively show that temperature fluctuations in frozen strawberries do not cause any significant quality changes other than those that would be expected at an equivalent steady temperature. These results are in agreement with those reported on frozen peaches and with other reports on the effect of fluctuating temperature *(2, 5)*.

Time-temperature equivalence. The relationships shown in Figure 12 indicate that equivalent subjective color and flavor changes are correlated with ascorbic-acid changes and objective color measurements. The time required for an equivalent subjective change in color or flavor varies logarithmically with temperature. However, as shown in Table 7 the amount of ascorbic acid oxidized or the change in Hunter "a" value, which represents relative redness, is essentially constant for equivalent subjective changes in the 10 to 25° F. range. In this range, 21 to 25% of the ascorbic acid is oxidized during the time required for 70 to 80% of the tasters to detect a color or flavor change at each temperature. This degree of subjective color and flavor change is also equivalent to a change in relative redness of approximately two Hunter "a" value units. Therefore, a change of 2 units in Hunter "a" value or an ascorbic acid loss of 20 to 25% is roughly equal to storage periods of approximately 5, 9, 28, 65, and 365 days for temperatures of 25, 20, 15, 10, and 0° F., respectively.

TABLE 7

Time-temperature equivalence with respect to color, flavor and ascorbic acid oxidation in composite cartons

Temp. ° F.	Color[1]	Flavor	Ascorbic acid loss, %	Δ Hunter "a" value
0	365	365	10	....
10	65	56	22	1.8
15	28	24	25	1.9
20	9	9	21	1.8
25	5	6	24	1.9

[1] Color and flavor are expressed in terms of days required for 70 to 80% correct judgments with the triangle test.

SUMMARY AND CONCLUSIONS

Fifty-five individual lots of commercially packed frozen strawberries have been evaluated for color and flavor changes over a 5-year period. Trained laboratory panels found significant flavor differences in approximately 90% of these lots within 2 weeks of storage at 20° F. Quality-control experts from frozen food plants indicated that storage at 20° F. for 4 to 6 weeks resulted in deteriorative changes which might be serious enough to cause consumer complaints. The rates of deteriorative changes occurring at temperatures above 0° F. have been found to vary exponentially with temperature. This was true of subjective color and flavor changes as well as loss of ascorbic acid and loss of relative redness as measured by the Hunter Color Difference Meter. For each 5° F. increase in temperature the rates of deterioration were increased 2- to 3-fold.

Type of package was found to be the most important single factor affecting the storage life of frozen strawberries held at temperatures above 0° F. Hermetic containers were far superior to the non-hermetic type in both flavor and ascorbic acid retention.

Storage at various time-temperature conditions indicated that deteriorative changes are additive and that the degree of change is the direct result of the sum of all the time-temperature experiences which the product may have encountered. A given experience may cause a minor change which is hardly noticeable, but if the product experiences a number of these minor changes, serious quality changes will eventually show up.

An approximation of the total quality loss or abuse which the product has experienced from the time of harvesting may be obtained by determining ascorbic acid and its various oxidation products.

An exponential relation between storage temperature and color, flavor, and ascorbic acid changes has been demonstrated.

Acknowledgment

The cooperation and assistance given by all the freezing plants where these commercial samples were obtained is gratefully acknowledged. The technical assistance of the following Western Utilization Research Branch personnel is also acknowledged: Mrs. Doris G. Sweny, Mrs. Margaret M. Stithem, Miss A. M. Mylne, and L. R. Leinbach.

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Microbiological Examination of Liquid Sugar Using Molecular Membrane Filters[a]

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(Manuscript received March 1, 1957)

ALTHOUGH LIQUID SUGAR has been available as an item of commerce for approximately 30 years, it is only in the last decade that an appreciable number of the food industries have availed themselves of the economic compensations afforded by the use of sugar in this form. To use liquid sugar, an industry need no longer be located in the immediate area of a refinery, for today sugar is available in this form distributed in tank cars and tank trucks not only directly from refineries but also from tank depots stocked by barge movements and located several hundred miles from the nearest refinery.

Industrial utilization of liquid sugar has been made possible by: (a) the ability of refineries to produce a product very low in initial yeast population; (b) the maintenance of dissolved solids high enough to discourage the development of yeasts; and (c) scrupulous maintenance of high standards of sanitation in the handling equipment. Over a period of time some of the yeast cells originally present in the sugar and those unavoidably introduced in the handling operations become acclimated to the high solids content (approximately 67%) and may increase in numbers sufficiently to become a serious source of contamination in the buyer's operations. Dilution may also occur in isolated pockets of bulk liquid sugar leading to a significant increase in the yeast count. Many liquid sugar users, therefore, have found it necessary to set up control procedures to be certain that microbiological contaminants are not introduced into their processes by the liquid sugar. Refineries have also had to set up procedures to control their own operations and to be certain that excessive numbers of yeasts are not present in their products as delivered.

For many years only the conventional plating methods, using media favorable for the cultivation of yeasts, were available. These suffered from the disadvantage of requiring a period of 4 to 5 days incubation before results were available. For the refineries and the larger users, this meant that the processes were being controlled historically instead of on a current basis. Furthermore, in order to secure statistically significant results at low yeast population densities it was necessary to plate an impractical number (25 or more) of replicate portions of each sample.

An attempt was made to adapt the presumptive test and most probable number techniques for water examination to the enumeration of yeasts in liquid sugar, using various liquid media favorable to the growth of yeasts. Some users also attempted to accelerate the estimation of yeast populations by passing samples through a laboratory model Sharples Super Centrifuge in which the bowl was lined with a removable cellophane film. Sediment collected on the lower portion of the film was then examined microscopically for presence of yeast cells. However, neither the centrifuge method nor the most probable number technique yielded results which could be correlated with plating methods as a means of predicting increasing yeast populations. Thus, although the newer procedures were more rapid, the results were not reliable.

Collodion membrances impervious to bacteria but permeable to their toxins were described by Sanerelli *(9)* in 1891. Over a period of years, other investigators from many countries studied the properties and improved the methods of production, but the membranes did not find widespread commercial application. During World War II the Germans so successfully used membrane filters for the rapid evaluation of the sanitary quality of water supplies in bombed cities and in the field, that at the end of the War a technical team was sent into Germany to study the techniques employed. The results of their studies, summarized by Goetz *(3)*, were released by the National Security Council in 1952, and membrane filters became commercially available to laboratories in the United States. The early reports *(1, 2, 3, 4, 5, 6)* covering the use of membrane filters indicated that bacterial counts on water samples could be obtained after about 6 hours incubation and, if proper differential media were employed, the presence or absence of organisms of sanitary significance could be confirmed, thus reducing the time required for these tests from days to a few hours. The studies reported in this paper were undertaken to develop a rapid method for detection of viable yeast cells in liquid sugar samples using membrane filters.

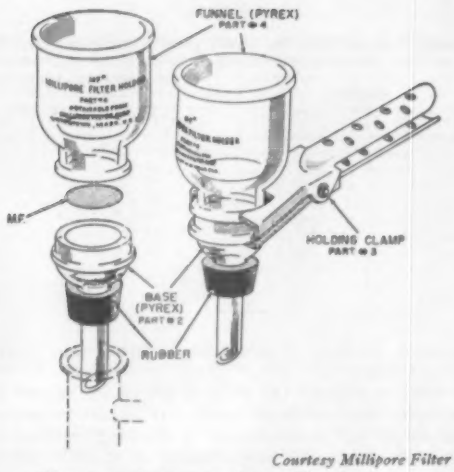
PROCEDURE

Liquid sugar samples used in these studies were obtained from 3 sources, namely: (a) daily tank truck deliveries from a commercial refinery; (b) daily plant control samples held for several months in sterile pint jars; and (c) liquid sugar inoculated with cultures which had become acclimated to a 67° Brix environment. Membrane filters, absorbent pads, filter and funnel base were stock items obtained from the Millipore Filter Corporation, Watertown, Massachusetts.

The filter assembly for collection of organisms consists of a filter base with a sintered glass disc on which the 47 mm. hydrosol grid disc membrane is placed and a funnel. Funnel, membrane filter, and base are locked together with a metal clamp and inserted in a one-hole stopper which is then placed in the mouth of a suction flask. (See Figure 1 for disassembled and assembled apparatus). To prevent the sample from adhering to the surface of the funnel and to insure complete collection of the organisms on the membrane, the funnel was treated with Desicote.[b] After the mouth of the funnel was covered with the top of a 100 mm. Petri dish, the entire filter assembly was wrapped in cotton flannel and kraft paper and sterilized in an

[a] Taken in part from a thesis submitted by M. C. Coleman to Georgetown University in partial fulfillment of the requirements for the Master of Science degree, June 1955.

[b] Product of Beckman Instruments, Inc.



Courtesy Millipore Filter Corp.

Figure 1. Pyrex membrane filter holder.

autoclave at 15 p.s.i. for 15 minutes. Filter discs and absorbent paper pads employed in the Petri dishes for incubation of the filters were wrapped separately in convenient size packages and sterilized in the autoclave at 10 p.s.i. for 10 minutes. This time and temperature were sufficient to sterilize the filters and avoided warping and brittleness caused by more severe sterilizing procedures. Petri dishes were sterilized in an oven at 180° C. for 2 hours.

Theoretically, one advantage of the membrane filter technique is that there is no limit to the size of the sample which can be examined. Practically, however, it was found that if large samples were filtered the filtration rate became very slow because the pores became plugged with microscopic debris such as small amounts of diatomaceous earth and vegetable char carried over from the refining process. It was found that 20 ml. samples diluted with 40 ml. of sterile distilled water could be filtered rapidly and yielded a satisfactory number of colonies on the membrane.

Twenty milliliter samples of liquid sugar were transferred aseptically to dilution bottles containing 50 ml. of sterile water. After thorough mixing, the diluted sample was transferred to the funnel of the filter unit containing a membrane disc. The mouth of the funnel was covered with the top of a 100 mm. Petri dish and suction was applied to the vacuum flask. After the sample had passed through the disc, the inside surface of the funnel was washed several times with 30 ml. portions of sterile distilled water, which was also drawn through the membrane, for the purpose of detaching the organisms that might have collected on the inner surface of the funnel. The clamp was then removed from the filter unit, the assembly separated and the membrane transferred aseptically to a 60 mm. Petri dish. The membrane was laid on the absorbent pad with the side containing the organisms up, using a rolling motion to prevent air bubbles from being trapped under the membrane, since the nutrient medium can only reach the organisms by diffusion through the filter. The 60 mm. Petri dishes were prepared for inoculation by placing a sterile absorbent pad in the bottom and pipetting 1.8 ml. of an appropriate sterile nutrient medium on top of the pad before placing the membrane on the pad. The dishes were inverted after adding the inoculated membrane and placed in a large tray containing a moist towel, since a moist environment is required to prevent excessive evaporation of the nutrient medium. Incubation was at 30° C.

After the incubation period was completed, each disc was transferred colony side up for 2 minutes to an absorbent pad wet with Loeffler's methylene blue solution containing 0.2 g. methylene blue, 60 ml. of 95% alcohol, 2 ml. of N/10 KOH and diluted to 200 ml. with distilled water to stain the colonies. The disc was then transferred to another absorbent pad wet with a glycerol-formaldehyde solution containing 50 ml. 95% glycerol, 50 ml. 37% formaldehyde and 100 ml. of water. The membrane was allowed to remain in contact with the fixative for 4 minutes to fix the colonies and condition the disc to prevent damage during drying and aging. The fixed discs were dried at 80° C. for 10 minutes and could then be examined immediately or at any time in the future. After examination, discs were filed for a permanent record.

Yeast colonies appear on the discs as dark blue dots on a light blue background. Figure 2 shows a typical membrane incubated 28 hours at 28–30° C. It was found that consistent results could not be obtained until the colonies developed to macroscopic size. However, in order to obtain counts after the shortest possible incubation time, it was found helpful to examine the membranes with the aid of a stereoscopic microscope at 13 diameters magnification. If less than 100 colonies appeared on the membrane, all colonies were counted and the number of organisms per unit volume calculated. If there were more than 100 colonies, that is, more than one colony per grid marked square, 3 fields were examined and the average number of colonies per field multiplied by 6 to obtain the number of cells per unit volume of sample. This procedure accelerated the examination of membranes containing a high density of colonies and is accurate to 2 significant figures when counts are greater than 100 per disc.

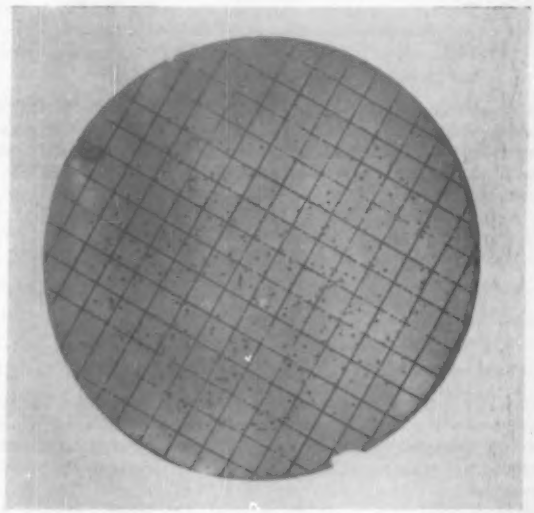


Figure 2. Yeast colonies on a typical membrane filter after 28 hours incubation at 28–30° C.

Although it was recognized that when dealing with low population densities a large number of replicate portions of each sample should be plated in order to obtain exact estimates of the population density, the number of samples which the control laboratory had to examine daily precluded inoculation of such a large number of replicate portions. It was the practice to plate duplicate one-ml. portions of each sample since the procedure was adequate to detect samples containing high counts. Inasmuch as the objective of this study was to compare the efficiency of the membrane filter technique with current control procedures, duplicate one-ml. portions of all samples examined by the membrane filter technique were plated by conventional methods on Difco Wort agar *(7)*. Control plates were incubated 5 days at 25° C.

It has been the practice of the sugar industry to report the results of the microbiological examination of sugar samples in terms of organisms per gram of dry solids. In order to avoid an additional calculation, it has been the practice in the control laboratory where these studies were made to report results as organisms per ml. of liquid sugar and the same method for recording results has been followed in this paper. The solids content of the samples did not vary enough from 67% to change the results significantly if a constant Brix of 67° is assumed and the results converted to organisms per gram of dry solids by multiplying the count per ml. by the factor 1.1.

After the organisms are collected on the filter disc, the disc is incubated in contact with a pad saturated with the nutrient medium. It is evident, therefore, that the nutrients must pass through the membrane by diffusion before being available to the organisms. Low molecular weight salts will diffuse rapidly whereas high molecular weight constituents diffuse quite slowly. Following this hypothesis, Clark and Kabler *(2)* demonstrated that increasing the concentration of high molecular weight constituents in the medium, thus increasing the diffusion rate, accelerated bacterial growth on membrane filters. Inasmuch as wort agar had proved to be a satisfactory medium for growing the organisms found in liquid sugar using the conventional plating technique, attempts were made to grow yeasts on membrane filters using media containing double and triple concentrations of the nutrients constituting the wort agar formula of Parfitt *(8)*. Although the double concentration medium yielded the best results, 4 to 5 days' incubation were required for optimum growth. In a further attempt to accelerate the growth rate, Parfitt's medium was modified as follows:

(1) Concentration of dipotassium hydrogen phosphate and ammonium chloride was doubled.
(2) Potassium dihydrogen phosphate was substituted for dipotassium hydrogen phosphate.
(3) The ratio of ammonium chloride to dipotassium hydrogen phosphate was increased.
(4) The ratio of ammonium chloride to potassium dihydrogen phosphate was increased.

None of these modifications reduced the incubation period to the degree sought and, after making similar modifications in other specialized media for the cultivation of yeasts, the following modified Sabouraud's medium was found basically to provide a promising growth rate:

20 g. Difco Neopeptone.
80 g. Difco Dextrose.
Distilled water to make one liter.
Autoclave at 15 p.s.i. for 15 minutes and after sterilizing add aseptically:
20,000 units Penicillin potassium G.
40,000 micrograms Streptomycin sulfate.
pH after sterilizing: 6.0.

It was noted in the preliminary screening work that bacteria present in the samples, or which were accidentally introduced during manipulation of the sample while it was being filtered, tended to overgrow the yeast colonies in the incubation period necessary for the yeasts to develop fully, even though the medium was designed to be selective for yeasts. It was not uncommon for a single colony of an air-borne spore forming bacterial species to completely cover the disc in 28 hours. The antibiotics were, therefore, incorporated in the formula to make the medium more selective for yeasts.

With the selection of a medium which gave rapid growth it was apparent that further investigation of the effect of the following 4 factors on the growth rate was required, namely: Temperature of incubation, pH of the medium, peptone source, and presence of antibiotics. A yeast culture obtained from a soured sample of sugar had been maintained in 67° Brix simple syrup long enough to become acclimated to liquid sugar containing 67% solids. For this series of experiments, portions of the acclimated culture in simple syrup were diluted with fresh, low count liquid sugar to provide samples having approximately the required population densities.

RESULTS

Table 1 shows the results obtained when 10 triplicate sets of membrane filters were incubated at 20, 25 and 30° C. for 28 hours. No filters were incubated at higher temperatures since it was observed in previous tests that there was marked inhibition of growth at 36° C. The samples were designed to cover the range from fairly low count sugar to very high counts. It will be noted that the highest counts were obtained when the discs were incubated at 30° C. Since the object in examining liquid sugar for viable yeast cells is to determine the maximum population, these results indicated that a 30° C. incubation temperature should be employed when making yeast assays with membrane filters.

TABLE 1

Optimum temperature for yeast growth on membrane filters

Sample No.	Colonies per ml. liquid sugar (28 hours incubation)		
	20° C.	25° C.	30° C.
1	3	8	14
2	12	20	32
3	15	20	30
4	18	23	43
5	20	24	33
6	26	30	55
7	47	75	102
8	72	110	180
9	125	210	357
10	1500	1800	4500

In order to evaluate the effect of pH on the rate of growth, a laboratory batch of liquid sugar was prepared containing 60 organisms per ml. as determined by plating 5 replicate one-ml. portions on wort agar. Sixteen batches of modified Sabouraud's medium were prepared at pH values ranging from 3.8 to 6.6 at approximately 0.2 pH unit increments by varying the ratio of KH_2PO_4 to K_2HPO_4 in the medium and by adding phosphoric acid. Three membrane filters were incubated in contact with the medium at each pH value after filtering 20 ml. of the stock sugar solution through each disc. At each pH one filter was examined after 22 hours incubation, the second after 28 hours and the third after 48 hours.

Results of these experiments (Table 2) demonstrate that the maximum count is obtained in the pH range 5.4 to 6.6 after 28 hours incubation at 30° C. and that varying the pH within this range does not accelerate the rate of growth of yeasts on membrane filters. The difficulty of distinguishing colonies after 22 hours incubation, even under the low power microscope, makes it advisable to incubate the filters 28 hours whenever possible. It will be noted that in a few instances the colony count after 28 hours is greater than after 48 hours incubation. Such results are due to fusion of colonies during the longer incubation period coupled with the normal variation in different portions of the syrup.

It was learned from private communications with the staff of the Millipore Filter Corporation that when examining water samples the peptone source exerted an appreciable affect on the rate of development of coliform organisms on membrane filters. A series of tests were, therefore, carried out substituting Difco Peptone and Albimi "M" Peptone for the Difco Neopeptone in the basic medium, using the basic medium as a control. Samples were prepared ranging in count from approximately 2 per ml. to 100 per ml. and 20 ml. portions of each sample were filtered through each of three membrane filters. One filter was incubated on the medium containing Difco Peptone, the second on the medium containing Difco Neopeptone and the third on the medium containing Albimi "M" Peptone. From Table 3,

TABLE 2

Effect of pH on growth of yeasts on membrane filters at 30° C.

Sample No.	Colonies/ml. on wort agar	Modified Sabouraud's medium			
		pH	Colonies/ml.		
			22 hrs.	28 hrs.	48 hrs.
1	60	6.6	52	98	53
2	60	6.3	23	74	63
3	60	6.1	88	155	96
4	60	6.0	6	91	62
5	60	5.8	54	39	70
6	60	5.6	27	60	56
7	60	5.4	15	70	54
8	60	5.2	26	4	45
9	60	5.0	3	9	60
10	60	4.9	0.4	16	65
11	60	4.7	0.5	0	25
12	60	4.4	0	11	60
13	60	4.2	0	10	26
14	60	4.0	0	0	16
15	60	3.8	0	0	0.1

TABLE 3

Effect of various peptone sources on growth of yeasts on membrane filters using modified Sabouraud's medium

Sample No.	Colonies/ml. (28 hrs. incubation at 30° C.)		
	Difco Peptone	Difco Neopeptone	Albimi "M" Peptone
1	2.0	1.8	2.3
2	2.0	5.4	0.6
3	4.0	4.2	3.8
4	5.0	5.2	5.2
5	8.6	8.4	8.8
6	13	14	13
7	15	17	14
8	15	16	15
9	26	28	24
10	92	96	90

showing the results obtained when the peptone source in the medium was varied, it will be noted that the counts obtained on all 3 media did not differ greatly. However, of the 10 samples run in this test, the medium containing Difco Neopeptone yielded the highest counts for 8 of the samples, thus suggesting a slight preference for the Neopeptone.

Although there are many references in the literature setting forth the effect of antibiotics on different strains of bacteria and on some pathogenic fungi, no data were found regarding the effect of antibiotics on yeasts. Since the incorporation of Penicillin and Streptomycin was so successful in suppressing bacterial contaminants and the antibiotics were, therefore, an essential component of the medium, a series of tests was made to determine whether the antibiotics had any tendency to suppress the yeast population. Ten samples of liquid sugar were prepared containing from one to approximately 90 yeast cells per ml. Twenty ml. portions of each sample were filtered through each of 2 membrane filters. One filter from each sample was incubated in contact with the basic Sabouraud's medium containing no antibiotics and the other in contact with the basic medium containing antibiotics. From Table 4 it will be noted that there is no significant difference between the counts obtained on the 2 media for any of the samples. The culture used in this test had been isolated previously from a fermented liquid sugar sample and, on the basis of the results presented in Table 4, it was concluded that incorporation of Penicillin and Streptomycin in the modified Sabouraud's medium probably would not exert an inhibitory effect when used as a routine control procedure.

Results of these controlled tests indicated that Sabouraud's medium at pH 6.0 containing Difco Neopeptone and antibiotics should produce counts after 28 hours incubation at 30° C. at least as high as those obtained using conventional plating methods and wort agar without the danger of overgrowth by air-borne contaminants. Therefore, a series of samples was examined by the routine control method (plating duplicate one-ml. portions on wort agar) and by incubating membrane filters 28 hours at 30° C. in contact with the modified Sabouraud's medium after filtering 20 ml. of the sample through the membrane. One hundred fifty samples were employed in this comparison. In order to extend the studies over a wide range of population densities, samples were obtained from 3 sources, namely: daily deliveries stored for extended periods to allow any yeast cells to multiply; and low count samples inoculated with osmophilic yeast cultures to produce high population densities. The wort agar plates were incubated 5 days at 25° C.

TABLE 4

Effects of antibiotics on growth of yeast on membrane filters using modified Sabouraud's medium

Sample No.	Colonies/ml. (28 hrs. incubation at 30° C.)	
	No antibiotics	With antibiotics
1	1	2
2	2	16
3	3	4
4	4	2
5	3	2
6	3	9
7	1	5
8	9	12
9	80	84
10	84	90

Figure 3 shows the frequency of occurrence of various population densities as indicated by the count on wort agar. From the graph it will be observed that 53% of the samples were found to contain less than five viable yeast cells per ml. and less than 10 cells per ml. were found in 63% of the samples. This distribution occurred because most of the samples represent daily refinery deliveries and high counts appear only occasionally in such samples.

Figure 4 represents a scatter diagram for the samples in which the wort agar counts in colonies per ml. of liquid sugar have been plotted as the abscissae and the membrane filter counts in the same units as ordinates. Due to the limitations of the plot area, counts greater than 70 per ml. on wort agar or greater than 100 per ml. on membrane filters have been omitted from Figure 4 but have been included in all calculations. Low counts found in a great many of the samples were plotted in the insert. In preparing the plot, counts of less than one per ml. on wort agar or less than one per 10 ml. on the membrane filters were interpreted as zero counts.

Results obtained by the 2 methods for 150 samples were used to calculate the following estimating equation expressing the relationship between wort agar counts and counts on membrane filters:

$$Yc = 1.23 + 1.34\ X$$

Where Yc represents the count on the membrane filter and X represents the wort agar count. This is also the equation of the line representing the average of all points plotted on the scatter diagram (Figure 4). The correlation coefficient was calculated from these results and found to be 0.958, thus indicating a high degree of correlation between the two methods.

DISCUSSION

Both the wort agar and membrane filter methods suffer from one shortcoming in that either method may fail to detect osmophilic yeasts which fail to readapt rapidly to media containing low sugar concentrations. Thus, either of these methods may not represent the total number of spoilage organisms. On the other hand, wort agar has been employed with sufficient success as a control procedure for operations using liquid sugar on a commercial scale that it is felt any method which shows a high degree of correlation with the wort agar

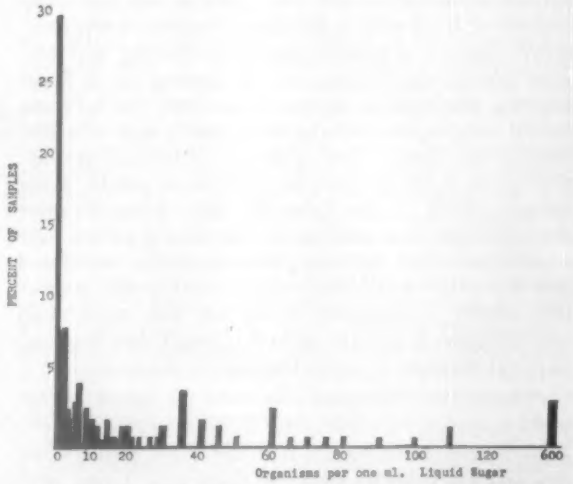


Figure 3. Comparison of numbers of yeast organisms found with frequency of occurrence in samples. Wort agar—5 days—28° C.

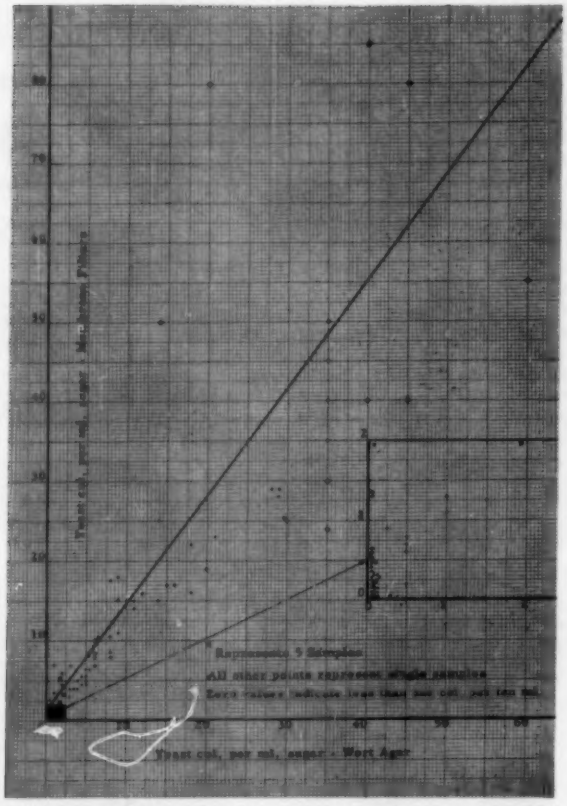


Figure 4. Yeast population estimates using wort agar and membrane filters.

method over a wide range of population densities for a large number of samples from several different sources should not introduce any additional hazards.

Over a period of years, experience has shown that duplicate wort agar pour plates from liquid sugar samples representing daily deliveries from refineries should generally be negative. Occasionally, as a result of the normal variation in different portions of the syrup coupled with the poor probability of getting a representative count on a small sample when dealing with low yeast population densities, counts ranging up to 5 per ml. on a single plate may be encountered. Such counts should only be encountered infrequently and it is reasonable to expect that generally duplicate one-ml. platings on wort agar will be negative for yeasts. Even though samples of the individual daily deliveries meet the established requirements for numbers of yeasts, over a period of time the organisms inevitably introduced into the system will multiply to an unacceptable population density. Unforeseen events may also cause rapid multiplication in isolated pockets of sugar thus resulting in larger numbers of yeasts than can be tolerated.

A large scale consumer may have a series of storage tanks operating on a minimum of a 3-day cycle in which a given tank is loaded one day, the sugar held for one day and the contents used the third day. Using wort agar and the conventional procedures, the equipment is reloaded and ready for testing before the results from the previous cycle are available and a large quantity of finished product might be infected before it became evident that the sugar from the preceding cycle contained excessive numbers of yeasts. Inasmuch as the membrane filter technique provides a means of obtaining results within 28 hours, sugar from a system operating on a 3-day cycle never need be used without knowledge of the microbiological quality. Similarly, this technique provides information regarding the sanitary condition of the handling equipment within a short enough period for sanitizing measures to be taken before a serious infection develops.

Turning again to Figure 4, it will be observed that there were no cases where, for the same sample, membrane filter counts were lower than one per ml. with wort agar counts high enough to be considered dangerous. Actually, no samples were found in which counts using the membrane filter were less than 10 per ml. and the wort agar counts were more than 10 per ml. Therefore, it may be concluded that at no time would the membrane filter indicate a satisfactory condition when the conventional plating method would have predicted an upward trend. The higher counts obtained using membrane filters provide an additional factor of safety and increased confidence for the liquid sugar user, yet the high degree of correlation between the two methods indicates that the use of the membrane filter method should not impose undue hardships on refiners. Furthermore, since the membrane filter technique gives statistically more reliable results at low population densities, upward trends in the results can be detected earlier than when using conventional plating techniques.

CONCLUSIONS

As a result of this study the following conclusions may be drawn:

(1) Using a modified Sabouraud's medium, optimum growth of yeast cells from liquid sugar occurs on membrane filters in 28 hours at 30° C. incubation temperature at pH values in the range 5.4 to 6.6.

(2) The peptone source employed in the medium does not appreciably affect either the number of viable cells found or the rate of colony development.

(3) Addition of Penicillin and Streptomycin in concentrations adequate to inhibit air-borne bacteria does not reduce the number of viable yeast cells below that found when using wort agar pour plates.

(4) Although there is a high degree of correlation between results obtained with the conventional wort agar pour plate method and the membrane filter method, as indicated by a correlation coefficient of 0.958, slightly higher counts are generally obtained with the membrane filter technique.

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Consistency Increase Caused by Adding Glycerine to Oil-Solid Systems

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The marked increase in consistency and reduction in oil separation when small amounts of glycerine are added to certain combinations of oil and solid material was first noted in connection with peanut butter and chocolate coating mixtures.

In 1939 a patent issued to members of this laboratory staff claimed a reduction in oil separation and improvement in texture of peanut butter by the addition of 0.1 to 2.0% of glycerine *(1)*. When added to melted sweet chocolate or semisweet chocolate coating mixtures (which contain sugar and sometimes milk solids), glycerine in amounts as small as 0.50 to 0.75% brought about an almost instantaneous thickening with an accompanying rise in melting point. Addition of as much as 5% of glycerine to chocolate liquor, however, had no appreciable effect on its melting point, indicating that a high proportion of finely divided solid was a necessary part of the system.

It was thought that this thickening effect might have further industrial application. Of particular interest were (a) the types of solids and fats which would bring the phenomenon into operation, (b) the effect of time, varied treatment, and ingredient ratio on the systems. The development of a theory explaining the phenomenon was also desired.

EXPERIMENTAL

Method of measurement. No usual method of viscosity measurement could be used on the systems to be studied. As they became thicker they tended to lose their ability to flow. Yet they were too soft to use depth of penetration as a measure of consistency.

A penetrometer-type device which had a bullet-shaped plunger permanently attached to a long brass tube was constructed to give comparative readings (plunger 1.2 cm. in diameter at largest point, tube 41 x 0.8 cm.). Consistency was measured by noting the time taken for the plunger to fall a distance of 20 cm. through the mixture in question. Samples being tested were contained in glass cylinders having interior dimensions of 25.5 x 3.5 cm. The weight of the plunger could be varied by dropping lead shot into the brass tube, which was open at the upper end. The two weights used were 42 and 84 g.

Preparation of samples. Initially, samples were prepared as follows: Weighed quantities of oil and solid were mixed thoroughly before adding the glycerine or the water (known to have an effect on these systems similar to that of glycerine). Mixing was done by hand with a spatula. After the addition of glycerine or water, mixing was continued until there was no further apparent increase in stiffness. Samples were then ready for penetrometer testing. (Further experimentation showed necessary modifications in this method. The final procedure is described subsequently.)

Variation of solids. First experiments dealt with corn oil (Mazola) and a variety of finely divided solids representative of carbohydrate, protein and inorganic materials. These included corn starch, wood flour, wheat flour, α-protein (soy), casein, zein, silicon dioxide, titanium dioxide (both oil and water dispersible) and carbon black. The ratio of solid to oil was varied to give similar initial consistencies for all the mixtures. Added glycerine and added water were tried in varied amounts. The glycerine used in all experiments was of 99.96% purity. In the majority of cases glycerine had a greater effect on consistency than did the water (Table 1). Unless obviously unnecessary (for example, in samples too stiff to measure) all values for the oil-solid systems are the average of at leasts 2 determinations, and those for the glycerine (or water)-oil-solid systems the average of a minimum of 4 readings. Consecutive readings on the oil and solid mixtures agreed so closely that additional repeat determinations were not necessary. In every case the first of the series of consecutive determinations was made immediately upon completion of mixing. Consistency change on standing for a period of hours or days was first noted in these samples.

The primarily carbohydrate materials—corn starch, wheat flour and wood flour (66% through 100 mesh)—gave the most stable systems and reasonably consistent results. Zein, casein and α-protein (soy) gave unstable systems, probably because of their partial solubility in glycerine and water. Of the inorganic group only silicon dioxide (Gold Bond) showed consistency changes on the addition of glycerine and water. Neither water-dispersible titanium dioxide nor carbon black showed any definite change. Results with oil-dispersible titanium dioxide were too erratic to be considered usable.

Representative system. The glycerine-oil-flour system was selected for intensive study. Wheat flour was chosen because it is readily available, is a common food material, and because the consistency change brought about by the addition of glycerine to wheat flour—corn oil mixtures was found to be very marked.

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TABLE 1

Consistency of glycerine-oil-solid systems and water-oil-solid systems

Material proportions	Average time for 20 cm. fall (sec.)[1]									
	No addition	Percentage added water					Percentage added glycerine			
		0.25	0.50	1	2	4	0.25	0.50	1	2	4
Corn starch + oil, 1:1	0.6			0.7	2.5				0.7	2.0	
Wood flour + oil, 1:4	6.4										
Wood flour + oil, 1:3	1.0		1.3	3.1	9.0				1.7	6.0	
Wheat flour + oil, 1:1	1.3			2.2	3.7				3.3	13.6	
a-Protein + oil, 1:1	1.3		1.9	2.3	2.8	4.0		2.1		7.4	5.7
Casein + oil, 3:4	1.6			2.5					T.S.[3]		
Zein + oil, 1:2	9.3			26.4					T.S.[3]		
SiO_2 + oil, 5:3	1.0	18.3[2]	18.6[2]	20.3[2]			T.S.[3]				
TiO_2 (W.D.) + oil, 3:4	2.1		1.1	1.5	2.9	1.6					0.8
Carbon black + oil, 1:5	T.S.[3]										
Carbon black + oil, 1:6	<0.5			<0.5	<0.5			<0.5	<0.5		....[4]

[1] Plunger weight is 24 g. unless otherwise noted.
[2] Plunger weight = 84 g.
[3] T.S. = Mixture too stiff to obtain penetrometer readings.
[4] Carbon black + oil, 1:6, + 5% glycerine = 0.5; + 10% Glyc. = 0.5–0.6. Corn oil was used.

Two samples of wheat flour were used, having moisture contents of 9.8 and 11.0%. Within the limit of error of the determinations, this moisture variation seemed to have no effect on the results.

A. *Variation in ingredient ratio.* The following ratios of oil to solid were tested: 2:3, 1:1, 3:2 and 2:1. The samples were prepared as described in the preceding section, and each series of readings was taken immediately upon completion of mixing. Average values were used in the preparation of Figure 1.

The consistency change for equal amounts of added glycerine became more marked as the proportion of flour in the mixture was increased. Twelve percent glycerine added to a 2:1 oil-to-flour system caused no appreciable stiffening immediately, while in the 2:3 oil-to-flour system 0.25% glycerine caused such a pronounced stiffening that its consistency could not be measured with the 42 gram plunger.

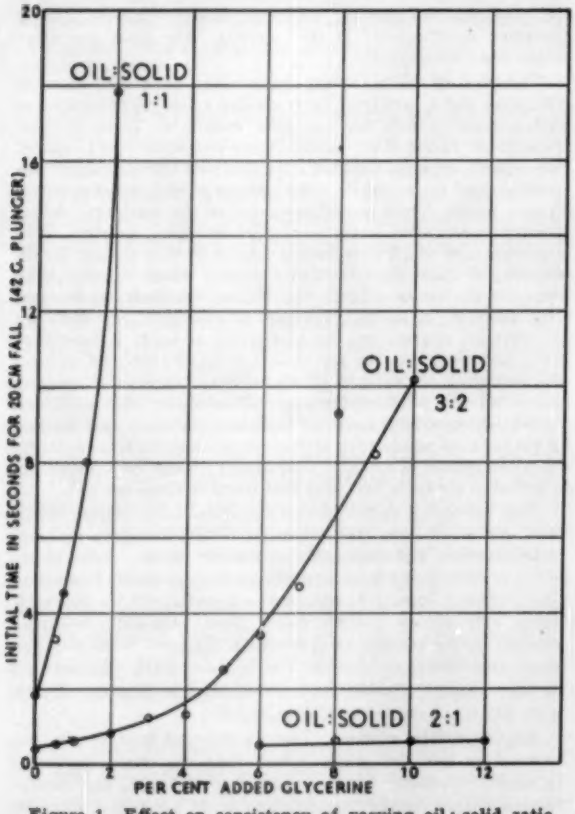

Figure 1. Effect on consistency of varying oil : solid ratio. (corn oil : wheat flour).

B. *Variation in method of mixing.* It was noted that samples containing identical quantities of ingredients sometimes differed considerably in consistency. (See Figure 2.) Although the B samples were presumably a duplication of the A samples and did show similar changes in viscosities, their viscosities were considerably higher. The effects of time, method of glycerine addition and amount of mixing were investigated in an effort to find the reason for these differences.

The possible effects on consistency of two methods of glycerine addition were studied; these were incremental addition, and addition in one portion. The total weight of glycerine added and the total number of mixing strokes were identical for each pair of samples. However, where incremental addition was made, the glycerine was added in 3 equal portions and one-third of the total amount of mixing followed each addition. Penetrometer readings were taken at accurately timed intervals, starting 20 minutes after the samples were prepared. Mixing between readings was identical for all.

All consistency-versus-time curves for the same oil-to-flour ratio were found to be of similar shape. No uniform difference in stiffness could be found between identical samples prepared by the two methods of glycerine addition. Figure 2 illustrates typical results obtained as described above. All samples were identical except for the mixing method employed. The pairs were prepared on successive days and each sample tested as soon as it was made.

C. *Variation in amount of mixing.* Another series of experiments was designed to disclose possible variation in consistency due to amount of mixing. No correlation was observed between the amount of mixing given the samples and either the maximum stiffness obtained or the time lapse before reaching maximum stiffness. (See Table 2.)

D. *Standard method.* On the basis of these data a standard method was established for treatment of the samples. It was as follows: (1) Oil and solids were weighed and thoroughly mixed together in a 400 ml. beaker to give a sample weighing 300 grams, (2) the total weight of glycerine necessary was added at one time, (3) after the glycerine addition the sample was stirred by hand for 300 strokes with a spatula having a tapering blade approximately 1.2 x 13 cm., (4) before each penetrometer reading the sample was given 10 strokes, (5) if more than 1 hour elapsed between readings, 40 strokes were given.

E. *Settling.* Beside the penetrometer tests two additional tests were tried as a means of rating the consistency of these mixtures. The depth of the oil layer on the surface of the samples after 24 hour settling in standard containers was measured, and also the number of ml. of oil on the surface of 15 ml.

TABLE 2

Effect of mixing just before testing on observed consistency wheat flour : corn oil, 1:1 plus 2% glycerine

Age of sample in hours	Time in seconds for 20 cm. fall of 42 g. plunger		
	Number of mixing strokes		
	10	50	100
	seconds	*seconds*	*seconds*
½	18	16.4	22.5
⅔	25.9	18.5	22.8
1	25.2	17.6	.....
1½	27.3	16.7	.....
1⅔	21.7	15.1	22.0
2	22.7	15.3	.....
3½	28.8	12.7	.....
4	21.1	11.9	17.4
5	20.0	11.7	13.3
24	16.4	11.5	11.1

samples after centrifuging was recorded. While these two sets of values could be correlated roughly with the penetrometer readings, the range of values between individual samples was not as great as with the penetrometer, nor were the oil separation vs. time curves as consistent as the curves obtained by the previous method of measurement. Representative results are given in Table 3.

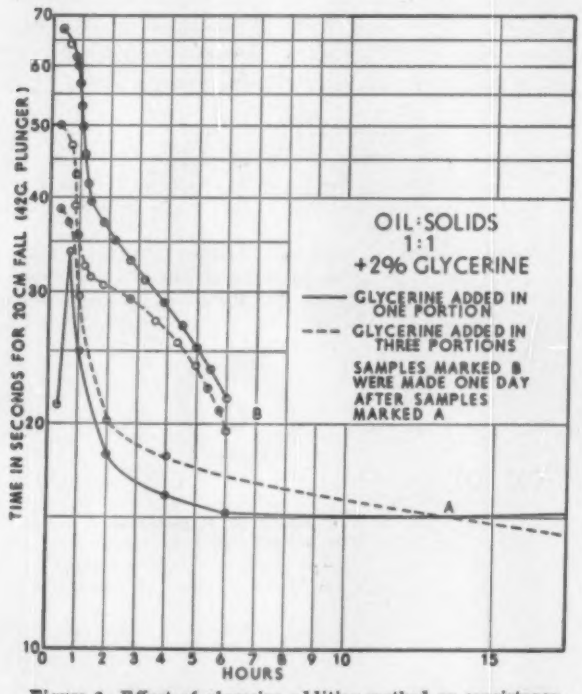

Figure 2. Effect of glycerine addition method on consistency of corn oil : wheat flour mixtures.

F. *Aging.* Some samples were tested repeatedly and it was found that consistency changed with time, usually increasing to a maximum within the first hour or two and then gradually decreasing to a fairly constant value after several hours. Representative results are given in Table 4. The same effect will be seen in the data of Table 2 and the curves of Figure 2.

Variation in fatty material. *Corn Oil.* These mixtures have been described in the preceding paragraphs.

Coconut Oil. A 1:1 coconut oil-wheat flour mixture was prepared to which glycerine additions of 1, 2 and 3% by weight were made. The curves obtained by plotting age of the sample vs. seconds required for the plunger fall were of the same general shape as those found for the corn-oil mixtures. See Figure 3.

TABLE 3

Consistency and oil separation of 6-day old samples

Wheat flour : corn oil, 2 : 3 plus	Penetrometer seconds 20 cm. fall, 42 g. weight	Oil separation [1]
1% glycerine	0.5, 0.4	5.1
3% glycerine	1.0, 1.0	4.5
5% glycerine	2.2, 2.0	4.0
7% glycerine	5.4, 4.8	3.5

[1] Ml. of oil on a 15 ml. sample after centrifuging.

Cocoa Butter. Samples made up of equal weights of melted cocoa butter and wheat flour were prepared and treated with 1, 2 and 3% added glycerine by weight. Samples were poured onto earthenware plates and aged for a minimum of 24 hours before testing. All were solid at the end of 24 hours.

To determine the relative consistency of these samples, the plates were put at a 20° incline in a 35° C. electric oven. At approximately half-hour intervals the oven temperature was raised by small increments.

TABLE 4

Change in consistency with time wheat flour : corn oil, 1:1, plus 2% glycerine

Age of sample	Time in seconds for 20 cm. fall of 42 g. plunger				
10 minutes	....	....	6	8	8
20 minutes	33	113	....	....	....
40 minutes	75	204	32	26	29
1 hour	58	146	26	22	25
2 hours	36	39	26	22	21
4 hours	28	26	....	17	....
5 hours	....	....	21	....	21
6 hours	....	....	....	17	....
1 day	21	19	15	14	15
2 days	....	....	15	16	13
3 days	20	18	....	....	13
5 days	....	....	13	13	....
6 days	....	....	13	11	11
7 days	15	15	14	12	13
28 days	17	15	15	13	15

Melting point of the cocoa butter used was 33–34° C. At 35° C. (the initial oven temperature) all samples containing only cocoa butter and wheat flour melted readily and flowed. At 40° C. all samples containing 1% glycerine were melted and had run down the plate, although their consistency remained slightly stiffer than that of the samples containing no glycerine. From 40–55° C. there was a slight seepage of fat from the 2 and 3% glycerine samples although they retained their original shapes. Maximum temperature used was 125° C. and even at this temperature the latter samples did not flow. Throughout the heating period the order of increasing stiffness of the samples remained the same as the order of increasing glycerine content. The 4 groups of samples gave no evidence of change in softening point as they increased in age.

Microscopic examination. Each of the mixtures of corn oil with powdered solids (except zein) investigated in the first stages of the work was also prepared with 1% of dyed glycerine and 1% of dyed water. These samples were examined microscopically. In every case the colored material was seen dispersed in the oil phase. In the majority of mixtures the colored droplets were seen to be coated with the solid or to be intimately associated with it. In the case of the water-dispersible titanium dioxide there were comparatively large colored areas of water and glycerine, poorly dispersed and seemingly encased in the solid. With carbon black there was random dispersion of small colored droplets in the oil, but the carbon did not seem attracted to the water or glycerine. With the two proteins and with the wheat and wood flours the dispersed liquid was seen as more irregular shaped droplets than with the other solids.

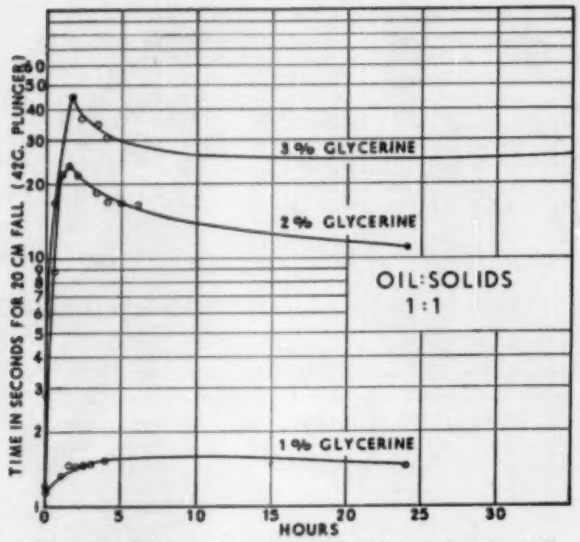

Figure 3. Effect of glycerine on consistency of coconut oil: wheat flour, 1:1, mixtures.

Both coconut oil and cocoa butter mixtures with wheat flour and 1 and 3% dyed glycerine had an appearance under the microscope similar to the mixtures containing corn oil.

DISCUSSION

Results have indicated that the stiffening phenomenon is related to some sort of emulsification process. Antagonism and phase inversion can occur in emulsions containing solid stabilizing agents as well as in those stabilized with soluble emulsifiers. Lewis and coauthors have stated that since carbon black emulsifies water in oil, while silica emulsifies oil in water, when silica is added to carbon black emulsification becomes either difficult or impossible *(2)*.

When an experiment was undertaken in line with this statement, the following facts were noted. When either glycerine or water was added to silica and corn oil mixtures a great increase in stiffness occurred. The increase was negligible in the case of carbon black and corn oil. When 1 to 2% by weight of carbon black was added to a stiff water-oil-silica mixture, the consistency of this mixture decreased sharply, going from 64 seconds to 3 seconds with the 84 gram plunger.

It is believed, therefore, that the consistency increase in these systems is due to the formation of a coarse water-in-oil or glycerine-in-oil emulsion which is stabilized by the finely divided solid present. Microscopic observation tends to confirm this theory.

SUMMARY

It has been previously reported that small amounts of glycerine will prevent or decrease oil separation and improve the texture of peanut butter and harden chocolate coating mixtures. It is now shown that these effects can be produced in a variety of solid-in-oil dispersions. Water will produce similar, usually smaller, effects, but it has the disadvantage of being volatile.

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Effect of Continuous Steam Injection of Tomato Juice on Film Deposition During Subsequent Concentration[a]

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(Manuscript received January 25, 1957)

High-temperature (210° F.) hot-broken tomato pulp characteristically shows a high content of natural pectin which has not been degraded by enzyme action. During concentration of such pulp a considerable amount of material is deposited as a film on heat exchange surfaces. Such film deposition represents a serious problem because it increases the time required for concentration. This adversely affects factory capacity as well as product quality and stability.

On the other hand, low-temperature (140° F.) hot-broken tomato pulp, in which the pectin has been degraded by natural enzymes, can be concentrated without film deposition on heat exchange surfaces. However, tomato concentrate prepared from low-temperature hot-broken tomato pulp characteristically is low in yield and shows poor weeping and viscosity qualities.

Silicone compounds have been applied to the heating coil in an attempt to control film deposition *(4, 6)*. Tests in our laboratory have shown that a thin film of silicone applied to the heat exchange surfaces tended to materially aid in film removal. Silicone treated coils can be cleaned in less time and with less effort than untreated coils. However, our work *(1)* showed that film deposition still occurred on the treated coils and

[a] Presented at the Sixteenth Annual Meeting of the Institute of Food Technologists, St. Louis, Missouri, June 12, 1956.

that the rate of evaporation was definitely reduced.

Therefore, a treatment or procedure which would allow the concentration of high-temperature hot-broken tomato pulp without film deposition on heat exchange surfaces would be very valuable to the tomato processing industry. It was found *(1)* that the injection of steam into a batch of tomato pulp until a pressure of 40 p.s.i.g. was reached prevented subsequent film formation on heat exchange coils.

The present study was designed to determine whether the steam injection method for treating high-temperature hot-broken tomato juice could be carried out on a continuous basis, the optimum time and temperature of steam injection and the quality of tomato concentrate prepared from the treated pulp.

EXPERIMENTAL EQUIPMENT AND METHODS

Equipment. Two pilot model atmospheric cookers were used in this study. The smaller cooker, described previously *(1)*, contained a copper heating coil having 0.92 sq. ft. heating area and a 0.03 in. wall. The larger cooker (F. H. Langsenkamp Co., Indianapolis, Indiana) was of stainless steel, 18 in. diam., and contained a copper heating coil that was made from ⅞ in. O. D. tubing, 18 gauge. The coil area, 1.44 sq. ft., and dimensions other than height were scaled to 1/60th the size of the commercial atmospheric cooker made by the same company. Steam pressure in the coils of both cookers was 90 to 95 p.s.i.g. In Figure 1 the larger cooker is shown on the right and the small cooker with a stainless steel sleeve inserted is on the left. The initial juice batch sizes were 12 gal. (106 lbs.) and 4.5 gal.

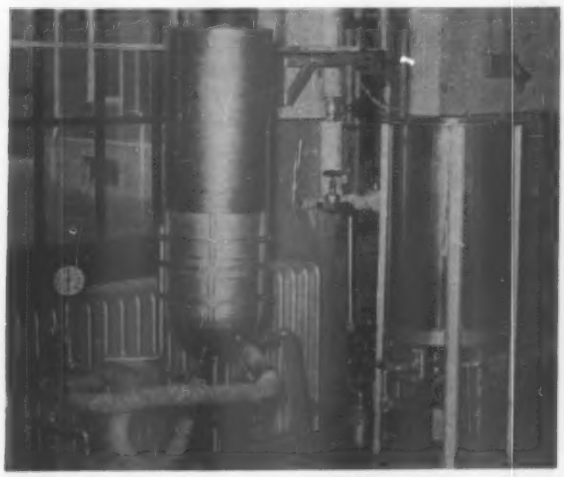

Figure 1. The large cooker (right) and the small cooker shown with sleeve inserted.

(39.6 lbs.) respectively. These were concentrated as nearly as possible to one-third the original volume.

Steam injection equipment included a storage tank, a 1½ in. positive displacement pump (Waukesha Pump Co., Waukesha, Wisconsin, Model 10BB) with variable speed drive, 1½ in. stainless tubing equipped with sanitary fittings, a spring loaded adjustable pressure control valve, a source of steam under pressure and the steam injection chamber.

This chamber, shown in Figure 2, was fabricated from a 5½ in. diam. stainless steel oxygen tank. Two ⅜ in. O. D. copper tubes were soldered into the side of the chamber for injecting steam. These tubes were inserted so that the steam entered the chamber tangentially and was directed around the periphery of the flowing column of liquid. This facilitated mixing of steam and pulp in the chamber and resulted in rapid heating of the pulp.

Juice was pumped from the holding tank upward through the steam injector installed in a vertical position, through the holding tube and the control valve to an open reservoir. The desired holding time was obtained by adjusting the pump speed and length of holding tube. Then the steam pressure reducing valve and the pressure control valve at the end of the holding tube were manipulated until the juice reached the experimental temperature. This was measured by means of a mercury-in-glass thermometer sealed in the end of the holding tube just ahead of the pressure control valve. The maximum conditions used were a temperature of 280° F. with a holding time of 9 minutes for the injection heated tomato juice.

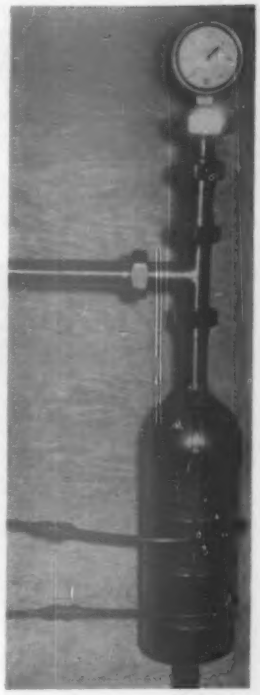

Figure 2. Apparatus for steam injection of tomato juice.

Preparation of pulp. In the general procedure, ripe Rutgers tomatoes were washed in a reel washer, destemmed, trimmed, inspected and passed through a tomato chopper into the large Langsenkamp cooker for hot breaking at various temperatures. Chopped tomato sufficient to cover the coils was added to the cooker and steam at full pressure was admitted to the coils. As soon as the hot-break temperature was reached, the tomatoes were chopped directly into the kettle. The temperature of the chopped tomato was maintained, in case of the high hot-break material, by controlling the rate of tomato feed to the chopper. Almost instantaneous heating of the chopped tomato was obtained by vigorous agitation.

The tomato pulp was then passed through a Langsenkamp laboratory finisher equipped with an 0.060 in. screen, filled into 30 lb. tins, frozen and stored at —40° F. Prior to use, the tins were allowed to partially defrost overnight at room temperature, the juice warmed to 140° F. in a steam jacketed kettle and then transferred to a storage tank until ready for steam injection. Such frozen and thawed tomato juice was previously found, by studies in our laboratory, to show evaporation rates and filming characteristics similar to those obtained before freezing.

In the case of several lots, a pre-blanching of whole tomatoes in live steam was carried out just before hot breaking. This treatment, similar to that discribed by McColloch *et al. (3)*, inactivated the pectin enzymes which are concentrated near the tomato surface and allowed very little pectin degradation.

Some lots of tomato juice were treated for particle size reduction immediately before the steam injection by passing through a comminutor or a colloid mill. For the first a standard Fitzmill was operated at about 3600 r.p.m. and equipped with a No. 1 screen (openings of 0.027 in. in diam.). For the second a Manton-Gaulin colloid mill was set with a clearance of 0.004 in. Several experimental runs were made in which the tomato juice was passed through the comminutor and then through the colloid mill.

Analytical methods. Soluble solids were determined with the Abbe refractometer. The procedure followed for total solids analysis was similar to that found in the A.O.A.C. with the exception that the sample was pre-dried in a forced-air circula-

tion oven for 4 hours at a temperature of 140° F. and finished dried in a vacuum oven at less than 100 mm. of mercury at 158° F. temperature for 16 hours.

Consistency of the concentrated product was measured with the Bostwick consistometer. This device is shown on the left in Figure 3 and is made by the Central Scientific Company. The tomato concentrate was adjusted to 80° F. before measurement. Flow time, before reading, was 30 seconds and measurements were recorded in centimeters. The procedure used for the blotter test, a quantitative measure of weeping, was as follows: 43 ml. of tomato product was poured onto a flat Whatman No. 3 filter paper; after a period of 2 minutes, the difference between

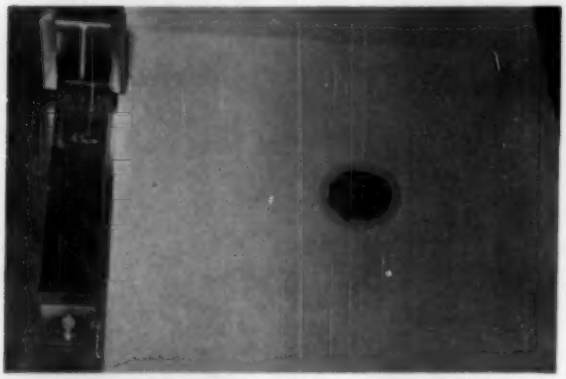

Figure 3. Bostwick consistometer (left) and blotter test for weeping showing annular ring of free serum.

the radius of the suspended solids and that of the serum was measured and expressed in millimeters.

Visual color was determined according to the P.M.A. standards for tomato puree *(5)*. Samples were evaluated within the fancy or standard grade in order to show whether the sample was high, medium or low in color for the specific grade category. A Hunter Color and Color Difference Meter with an Rd scale was used for color measurement. A tomato red tile was used for standardizing and readings were taken on the a and b scales. These values were used for calculation of the a/b ratio.

The average rate of water evaporation during concentration of a batch of juice was given in pounds per minute by

$$\frac{W}{T}\left(1 - \frac{S_o}{S_f}\right)$$

where W is original weight of batch in pounds, T is total cooking time in minutes. S_o is percent total solids in original juice and S_f is percent total solids in final concentrate.

Each batch of juice was taste tested before and after concentration for the presence of scorched or other off-flavor. This was done to show whether steam injection caused off-flavors.

RESULTS AND DISCUSSION

Effect of hot-break temperature on film formation. A comparison of filming characteristics was made between low-temperature and high-temperature hot-broken tomato pulp. Both the large and small cookers were used in this study. The results of this experiment are presented in Table 1.

The evaporation rate for each pulp was considerably higher in case of the small cooker. This was in line with previous findings and can be explained by the fact that the ratio of coil surface to cooker volume was less for the large cooker. Hydrostatic head of product over the cooking coils was also greater with the large cooker.

Low-temperature (140° F.) hot-broken juice did not deposit film on the coils during evaporation as evidenced by the short cooking times and high evaporation rates. In the case of both cookers the high-temperature (210° F.) hot-broken pulp deposited a heavy film on the copper heat exchange coils. Here the longer cooking times and lower evaporation rates clearly show the adverse effect of film deposition. These results confirmed previous findings in this laboratory *(1)*.

Examination of weeping and consistency (Bostwick) data (Table 1) for the concentrated product shows a marked superiority for the high-temperature hot-broken pulp. Weeping of the low-temperature hot-broken concentrate was 18 and 16 mm. while the high-temperature hot-broken concentrate was 0.5 and 1 mm. respectively. This difference is very large and indicated excellent pectin preservation in the high-temperature product and nearly complete degradation of pectin in the low-temperature concentrate. Consistency differences (Table 1) between high-temperature and low-temperature hot-broken concentrates were considered as highly significant in favor of the high-temperature hot-broken product. Since the differences shown by the color data were small and could not be attributed to treatment variations, these data are not presented here.

Effect of time and temperature of steam injection on film formation. Previous studies *(1)* with a stationary system indicated that a steam injection pressure of 40 p.s.i.g. and temperature of 285° F. with a holding time of one minute completely eliminated film deposition factors in high-temperature hot-broken tomato pulp. It was desired to determine the approximate minimum conditions of time and temperature of continuous steam injection of high-temperature hot-broken pulp which would inhibit film deposition on heat exchange surfaces. Steam injection treatments of 3.6 and 8.4 minutes holding times at a temperature of 270° F. were applied to high-temperature hot-broken tomato pulp for this experiment. The results are presented in Table 2.

Examination of the data shows that the steam injection treatments at 270° F. reduced but did not eliminate

TABLE 1

Effect of hot-break temperature on subsequent film formation on heat exchange coils during concentration of tomato juice

Cooker	Temperature of hot break °F.	Average evaporation rate lbs./min.	Presence of film on coil	Evaporation time, min.	Total solids content		Weeping		Bostwick viscosity after evap. cm.
					Before evap. %	After evap. %	Before evap. mm.	After evap. mm.	
small	140	3.9	none	6.0	6.7	16.2	30	18	8.2
small	210	2.7	heavy	8.5	6.7	15.6	14	1	6.0
large	140	3.1	none	20.0	6.8	16.1	24	16	9.0
large	210	2.4	heavy	26.0	6.9	16.8	30	0.5	5.4

TABLE 2

Effect of juice temperature and holding time during steam injection on subsequent film formation using 210° F. hot-break juice

Tomato batch and run	Cooker	Injection temperature ° F.	Injection holding time, min.	Average evaporation rate lbs./min.	Presence of film on coil	Evaporation time, min.	Total solids		Weeping		Bostwick viscosity, after evap. cm.
							Before evap. %	After evap. %	Before evap. mm.	After evap. mm.	
1–6	large	270	8.4	2.9	none	23.0	5.7	15.4	18	2	8.2
1–1	small	control	none	2.7	heavy	9.5	6.0	16.6	19	2	6.8
1–2	small	270	3.6	3.4	medium	7.0	5.7	14.1	14	5	9.2
1–3	small	270	3.6	3.2	medium	8.0	5.7	16.0	16	4	7.5
1–4	small	270	8.4	3.4	light	7.0	5.6	13.6	17	4	8.6
1–5	small	270	8.4	3.3	light	7.0	5.7	13.4	28	7	8.8
2–1	small	control	none	2.4	very heavy	10.0	6.7	16.6	15	0.5	5.4
2–2	small	280	0.65	3.0	medium	8.0	6.4	16.3	16	3	7.0
2–3	small	280	0.65	3.0	medium	8.0	6.4	16.3	23	3	7.1
2–4	small	280	0.88	3.1	medium	7.0	6.6	14.4	20	3	8.6
2–5	small	280	0.88	3.2	medium	7.0	6.3	14.8	18	5	8.4
3–6	large	280	3.1	2.9	none	21.0	6.8	16.0	16	2	6.6
3–1	small	control	none	2.5	very heavy	9.5	7.0	17.6	12	2	5.0
3–2	small	280	1.7	3.1	very light	7.5	6.6	15.9	16	3	6.5
3–3	small	280	1.7	2.9	very light	8.0	6.9	16.7	15	3	6.6
3–4	small	280	3.1	3.3	none	7.0	6.6	15.8	14	4	6.8
3–5	small	280	3.1	3.3	none	7.0	6.6	16.1	11	1	6.0

film deposition. Steam injection for 3.6 min. at 270° F. substantially reduced cooking time and increased the evaporation rate as compared to the control which was not steam injected. Increasing this holding time from 3.6 to 8.4 min. did not materially affect the film deposition characteristics of the tomato pulp since the average evaporation rate remained the same. The important finding of this work at 270° F. was the definite advantage found for steam injection.

In the final series of experiments in this study (Table 2) the steam injection temperature was raised to about 280° F. and holding times were 0.65, 0.88, 1.7 and 3.1 min., respectively. Holding times up to and including 1.7 min. reduced the tendency for film deposition by 210° F. hot-broken tomato pulp. However, a holding time of 3.1 min. at the steam injection temperature of 280° F. prevented film deposition. Filming characteristics were tested in both the small and large cookers and results showed that the filming tendency was controlled. This was evidenced by a clear coil, short cooking time and increased evaporation rate.

Steam injection at 280° F. resulted in slightly higher weeping and somewhat impaired consistency as shown by the blotter test and Bostwick viscosity, respectively. However, steam injection of high-temperature hot-broken tomato pulp resulted in a much better overall product than that obtained by using a low temperature hot break without steam injection.

The Hunter color and color difference meter a/b ratios of the control samples were generally slightly higher than those of the steam injected concentrates. Visual color or P.M.A. grades indicated little if any difference among the samples. It must be concluded that, if color differences existed, the methods of evaluation were not sensitive enough to demonstrate these differences.

Effect of blanching whole tomatoes prior to hot breaking on film formation. Whole tomatoes were given a steam blanch immediately prior to hot breaking at 210° F. This treatment is highly effective for rapid and complete enzyme inactivation which results in maximum pectin retention in the hot-broken pulp. Experiments were carried out to determine the effectiveness of steam injection on blanched high-temperature hot-broken tomato pulp and to show whether this method of hot breaking yielded superior tomato concentrates.

Steam injection at a temperature of 280° F. for 3.2, 5.4, and 8.6 minutes did not completely eliminate filming tendencies of blanched high-temperature hot-broken tomato pulp (Table 3). However, cooking times and evaporation rates of these steam injected samples were almost as desirable as those found for low-temperature hot-broken tomato pulp (Table 1). Increasing the holding time from 3.2 to 8.6 min. at the steam injection temperature of 280° F. did not reduce the filming characteristics of the tomato juice. Perhaps the use of

TABLE 3

Effect of steam injection at 280° F. on the film forming property of tomato juice produced by blanching the whole tomato prior to hot breaking at 210° F. (juice concentrated in small evaporator)

Tomato batch and run	Injection holding time, min.	Average evaporation rate lbs./min.	Presence of film on coil	Evaporation time, min.	Total solids		Weeping		Bostwick viscosity after evap. cm.
					Before evap. %	After evap. %	Before evap. mm.	After evap. mm.	
1–1	control	2.0	extremely heavy	11.0	....	15.1	....	0.5	7.2
1–2	3.2	3.0	light	8.0	5.8	14.9	15	3	7.1
1–3	3.2	3.0	light	8.0	5.9	14.9	16	3	7.3
2–1	control	2.9	heavy	8.0	6.0	14.8	16	3	8.8
2–2	5.4	3.4	light	7.0	5.5	13.9	16	6	8.4
2–3	5.4	3.4	light	7.0	5.6	13.9	26	4	9.3
2–4	8.6	3.5	light	7.0	5.3	13.8	18	5	9.0
2–5	8.6	3.3	light	7.0	5.3	12.8	20	8	10.4

higher steam injection temperatures might have eliminated filming in blanched high-temperature hot-broken tomato pulp. However, it was not possible to adjust this injection apparatus to operate at a temperature above 280° F.

Examination of weeping and Bostwick viscosity data in Tables 2 and 3 shows that the concentrate from the regular high-temperature hot-broken pulp exhibited more favorable results in these two criteria than did the concentrate produced from tomatoes that had been blanched prior to the high-temperature hot break. However, it must be considered that this phase of the study covered only two lots of tomato pulp and other varieties, for instance, may have given the expected results.

Color data, P.M.A. visual grades, and Hunter a/b ratios did not show any definite trends in regard to blanching of the whole tomatoes.

Effect of particle size reduction prior to steam injection on film formation. The effects of particle size reduction of the tomato fiber prior to steam injection were studied. High-temperature hot-broken tomato pulp served as raw material in each case. In some experiments the pulp was passed through a comminutor and in others through the comminutor and then a colloid mill before injection with steam. A steam injection temperature of 280° F. and holding times of 2.8, 3.0 and 9.1 minutes were used. Several control batches received neither size reduction nor injection treatments; several received only the first treatment and one received only the latter. Both the small and large cookers were employed for concentration. These data are presented in Table 4.

When control lots, neither treatment, were compared with comminuted but not steam injected samples of tomato pulp (batches 2 and 3, runs 1 and 2, Table 4) it was seen that the film forming tendency was about the same or perhaps somewhat less in the comminuted samples. In both cases a heavy film was deposited on the coils. No real differences between the two were found in the weeping results for the concentrates. However, the Bostwick data showed a better viscosity for the comminuted over the control samples. This finding agrees with previously published studies *(2)* on the effect of fiber size on viscosity of tomato pulp.

All comminuted samples which were steam injected at 280° F. and held for 2.8 and 3.0 minutes and subsequently concentrated exhibited a slight filming on the heat exchange coils. However, this film was much lighter in nature than the film deposition which occurred when either the controls or the comminuted but not steam injected samples were concentrated. The weeping and Bostwick data compared favorably with other steam injection treatments shown in Tables 1, 2, and 3.

When a 9.1 minute holding period was used with the 280° F. injection temperature, the coils in the small cooker appeared practically clear and the evaporation rate was the same as found with the 3.0 minute holding time. However, the data showed that both the weeping and viscosity characteristics of the final concentrate were definitely inferior. Apparently holding the pulp at 280° F. for 9.1 minutes was so severe a heat treatment that the tomato pectin was partially degraded. This would account for the increased weeping and lowered viscosity.

When the particle size was further reduced by passing comminuted pulp through a colloid mill (batch 1, Table 4), the amount of film deposition as indicated by cooking time and evaporation rate was essentially the same as when comminution was the sole treatment (batch 2, Table 4).

Tomato batch 4, Table 4, was used to obtain information on the large cooker. Comminuting without steam injection gave inferior results as compared to either comminuting plus injection or steam injection alone. Since the latter two runs gave the same evaporation rate it was shown that comminuting offered no advantage when combined with the steam injection treatment. Perhaps comminuting would be desirable at

TABLE 4

Effect of particle size reduction of 210° F. hot-break juice in combination with steam injection at 280° F. on subsequent film formation

Tomato batch and run	Cooker	Particle reduction treatment	Injection holding time, min.	Average evap. rate lbs./min.	Presence of film	Evaporation time, min.	Total solids		Weeping		Bostwick viscosity, after evap. cm.
							Before evap. %	After evap. %	Before evap. mm.	After evap. mm.	
1–1	small	control	none	2.8	heavy	8.0	6.1	13.8	19	4	9.0
1–2	small	comminutor	none	2.9	heavy	7.0	6.6	14.6	21	3	4.7
1–3	small	comminutor + colloid mill	9.1	3.3	light	7.0	5.5	13.1	16	10	10.0
1–4	small	comminutor + colloid mill	9.1	3.3	light	7.3	5.7	13.6	18	9	9.2
2–1	small	control	none	2.2	very heavy	9.5	6.0	13.0	18	8	8.2
2–2	small	comminutor	none	2.7	heavy	8.0	6.1	13.3	22	7	7.2
2–3	small	comminutor	9.1	3.2	none	7.0	5.4	12.4	24	12	8.9
2–4	small	comminutor	9.1	3.4	none	7.0	5.3	13.3	20	11	8.0
3–1	small	control	none	2.8	very heavy	8.0	6.2	14.0	16	2	8.1
3–2	small	comminutor	none	2.7	very heavy	8.5	6.2	15.0	17	2	7.5
3–3	small	comminutor	3.0	3.4	very light	7.0	5.9	14.8	15	4	7.9
3–4	small	comminutor	3.0	3.3	very light	7.0	5.8	14.6	18	4	8.1
4–1	small	control	none	2.7	very heavy	8.5	5.9	13.9	19	3	7.4
4–2	large	comminutor	none	2.6	heavy	23.0	6.1	14.4	24	4	7.2
4–3	large	none	2.8	2.9	very light	21.0	5.4	12.9	18	8	10.3
4–4	large	comminutor	2.8	2.9	very light	22.0	5.8	14.2	20	8	7.8

some other stage in the processing such as after steam injection or concentration.

Effect of steam injection on flavor. Of the total 45 treatments, 7 produced samples rated other than good in flavor. Three of these were judged very slightly scorched after concentration but not before, i.e. after steam injection. The 8 samples from the maximum treatment of 9.1 min. at 280° F. ranged from good to poor but none were considered scorched to any degree. These results indicated that the steam injection treatment probably did not present a flavor problem but this should be ascertained by the individual processor under his specific conditions.

SUMMARY AND CONCLUSIONS

A comparison was made of the film deposition characteristics of low-temperature (140° F.) and high-temperature (210° F.) hot-broken tomato pulp during concentration at atmospheric pressure. Low-temperature hot-broken pulp, which characteristically contains enzymatically degraded pectin material, was concentrated without film deposition. However, the high-temperature hot-broken juice, in which the pectin substances were preserved, deposited a heavy film on the heat exchange coils during evaporation. Evaporation rates were substantially higher in the low-temperature hot-broken product but weeping and consistency qualities of the high-temperature hot-broken samples were definitely superior.

Equipment which allowed the continuous heating of tomato pulp by direct steam injection was fabricated and assembled. Steam injection temperatures as high as 280° F. with holding times as long as 9.1 minutes were employed. Treatments were evaluated by the degree of film deposited on the heat exchange coils, by the total cooking time, total and soluble solids, weeping, consistency as determined by Bostwick, P.M.A. visual grade, Hunter Color and Color Difference Meter a/b ratio and evaporation rate.

Under the conditions and equipment used in this study steam injection of high-temperature hot-broken tomato pulp at 280° F. for 3.1 minutes prevented film deposition during subsequent evaporation. This treatment decreased concentration time and increased evaporation rate but it produced a slight adverse effect on weeping and consistency of the concentrated product. Blanching of the whole tomatoes prior to hot breaking increased film deposition by the pulp and reduced effectiveness of the steam injection treatments. Particle size reduction as obtained with a comminutor and a colloid mill was not desirable either alone or in combination with steam injection.

Of the 45 steam injection treatments only three resulted in tomato concentrates which were judged as scorched to a very slight degree. No objective quality changes which might be considered significant were noted in the concentrates produced from this pulp. However, there remains the possibility of latent heat damage becoming evident upon storage of the concentrate. Since storage tests were not carried out, predictions of product stability cannot be made. Although preliminary work indicated otherwise, the use of frozen juice as raw material may have had an effect on the results. The value of this steam injection treatment should be determined on a pilot plant scale before application to full production.

Acknowledgment

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Notes and Letters

Addenda to
A Quick, Rank Test for Significance of Differences in Multiple Comparisons

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and
Amihud Kramer
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(Manuscript received April 5, 1957)

THE paper referred to in the title was published recently *(5)* in FOOD TECHNOLOGY. Since the paper appeared, much interest has been shown in it and many comments and requests for copies have been received. Among the comments were numerous requests that the tables be extended. In reconsidering these tables, we concluded that users should be made aware of certain limitations in the method, arising from fundamental considerations of statistical theory and philosophy. It is the objective of this short note to clarify the situations of appropriate application of the published tables, and to define more clearly how the tables may be used.

The term "multiple comparisons" is used here in the sense of an extension of "paired comparisons", as used in taste panel terminology, and is not to be confused with the term as used in statistics by D. B. Duncan *(2)* and others for procedures for grouping means following the analysis of variance.

Tables 1 and 2 are useful in the following situation:

(i) t treatments are ranked, with ranks 1, 2, . . . , t, in each of n replications.

(ii) A particular treatment is picked *in advance* for consideration.

(iii) It may be assumed that the remaining (t-1) treatments do not differ, that is, are indistinguishable.

(iv) We test the null hypothesis that the specified treatment is also like the remaining set of indistinguishable treatments. Under the assumption of the null hypothesis and in view of the assumption (iii), all treatments are indistinguishable; this implies that it is equally likely that any treatment receives any of the ranks in each replication of the experiment.

(v) We use the rank total of the specified treatment as our test statistic and compare this observed rank total with entries in Table 1 or Table 2, depending on our choice of a level of significance. This procedure follows in the same way as consideration of treatment 2 of the first example of *(5) if treatment 2 had been specified in advance.*

Now the appropriateness of comparing any other rank totals besides that of treatment 2 specified in advance with entries in Tables 1 and 2 is questionable because we can no longer assume that the remaining treatments are indistinguishable, since treatment 2 had a very low rank sum. No procedure is available for the grouping of rank totals for n rankings of t treatments. Rank totals for various treatments in such experiments are correlated and procedures for "multiple comparisons" in the sense of Duncan *(2)* would indeed be very difficult to work out and would depend on "extreme value" theory for such distributions and on philosophical questions now under disagreement by statisticians. It is suggested therefore that the use of Tables 1 and 2 beyond that outlined above [(i)–(v)] be regarded as only indicative of possible treatment differences and such use is not substantiated by statistical distribution theory. An over-all test of treatment equality for n rankings of t items may be made and would be an analogue to the F-test of analysis of variance. Examples of this procedure appear in many places and the method has been discussed by numerous authors in statistical literature. We note examples, given by M. G. Kendall *(3, 4)* and Bradley *(1)*, that are easily accessible.

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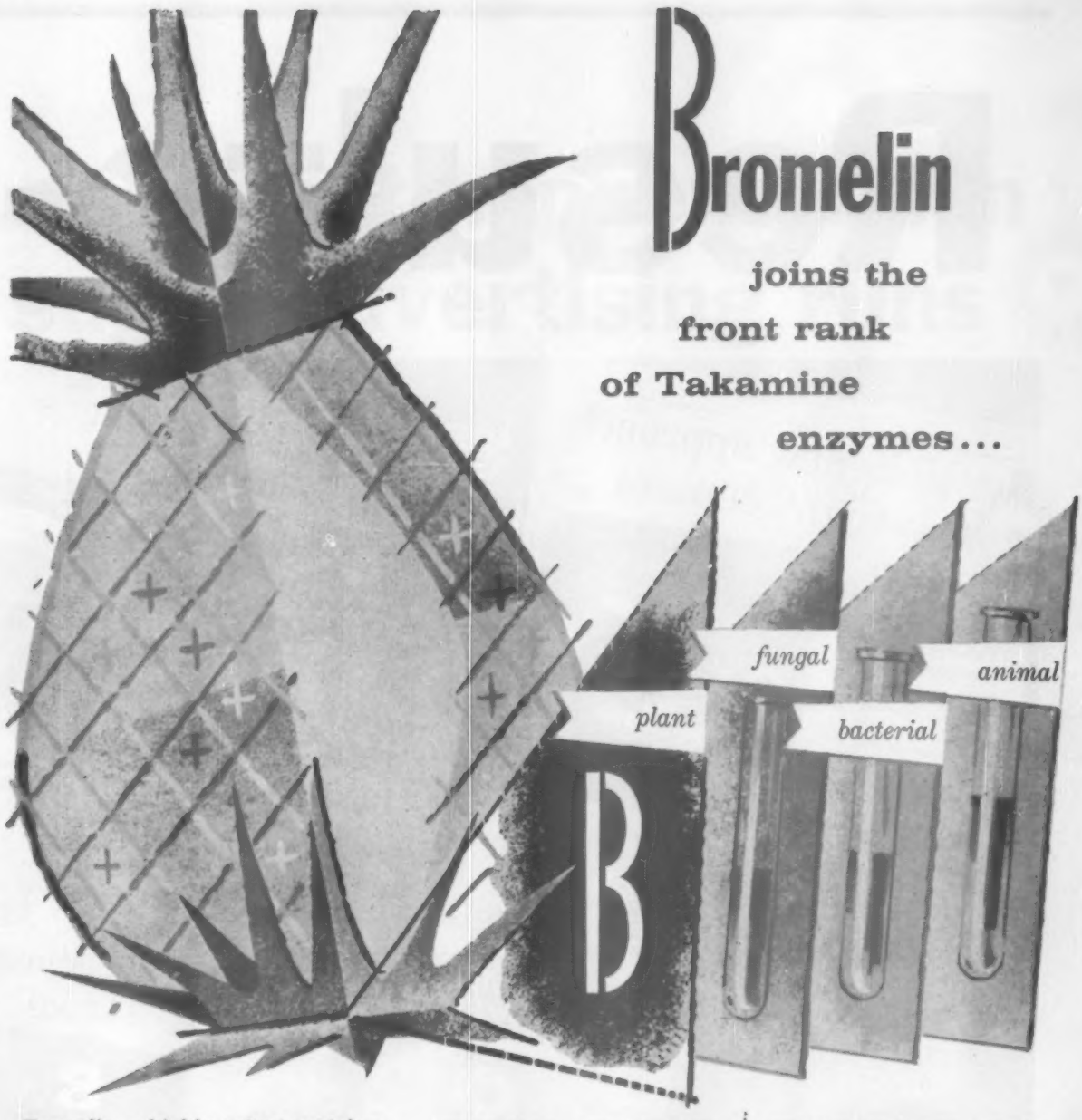

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DIASTASES — For liquefaction and hydrolysis of starch to produce soluble dextrins and sugars. Also removes starch, eliminating filtration problems and turbidity.

PECTIC ENZYMES — For the hydrolysis of pectins in fruit and fruit juices in order to speed processing and to make fruit juices sparkling clear for consumer appeal.

PROTEINASES — For the modification and hydrolysis of proteins in food manufacturing and pharmaceutical operations.

GLUCOSE-OXIDASE — To prevent browning due to glucose or oxygen, and to increase shelf-life of beverage products.

Takamine Enzymes
make it taste *better*,
look *better*, sell *better*

For complete information write to:

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Results--

Sensible new approach to weight control
You eat the foods you like
Cut down instead of cutting out
Sugar is a basic element in this modern concept for these important reasons:
1. Sugar helps to keep your appetite satisfied on less food.
2. By making your diet interesting, sugar can help you to stay on it.
3. Ounce for ounce, no other food supplies energy so fast, with so few calories. So sugar helps overcome a lack of energy while you are dieting.
18 CALORIES!
SUGAR INFORMATION, INC.
The problem of fatigue in reducing diets
Why do so many people on diets feel tired—lose mental alertness?
Can energy stay up while pounds go down?
What kind of food do you need to keep up your energy?
Recent scientific findings show how sugar can help you lose weight with less hunger—less fatigue
18 CALORIES!
SUGAR INFORMATION, INC.
A
B
C
How sugar can help you reduce —and stay there
Why do people find it easier to lose weight than keep it off?
Do you dread starting "another diet"?
Why does overdieting often fail to control overweight?
New facts show how sugar helps you reach your desirable weight, and hold it!
18 CALORIES!

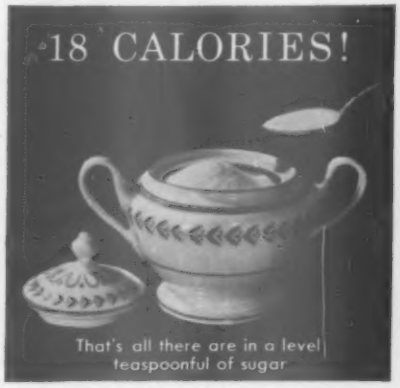
Look what happens when sugar advertising runs

Ad "A" Over 200,000 copies of "The Scientific Nibble" booklet were sent out as a result of initial inquiries coming in from this ad. The continuing flood of requests made second and third printings necessary.

Ad "B" Over half of the women who read the newspapers remembered the ad, according to a readership study. Most important, a high majority of these women were *weight watchers.* The ad scored unusually high on readership and idea acceptance.

Ad "C" This ad will appear in July, the first of a new series in newspapers and magazines reaching 40% of the families in the U.S. It, too, will be read by millions interested in watching their weight.

And have you seen the numerous magazine and newspaper articles warning the public against fad diets? They add strength to the Sugar Information campaigns, helping restore confidence in normal foods and eating habits.



Sugar means sucrose (cane and beet sugar).

SUGAR INFORMATION, INC., NEW YORK 5, NEW YORK

REGIONAL SECTIONS

(Continued from page 24 preceding technical papers)

resistance to disease and the degenerative processes. Such diets must be completely balanced in every component: a balance of amino acids in the proteins; a balance of fats, carbohydrates, and proteins; a balance of vitamins, minerals, and salts.

Discussing items of current public interest, Dr. Allison noted that fortification of foods with lysine is useful where amino acid imbalance of the diet would otherwise exist. In this situation, the addition of lysine in amounts to assure balance seemed justified, although lysine beyond that needed to achieve optimum balance has no dietary value. On the matter of cholesterol, in which there is such widespread interest today, he commented that present knowledge indicates that the control of the cholesterol levels in the body is not related to the ingestion of cholesterol itself, but rather to the balance of fatty acids in the diet, with particularly emphasis on the balance of saturated and unsaturated fatty acids. It now appears that the unsaturated fatty acids have the ability of transporting cholesterol from the system, thus preventing deposits and build-up.

Dr. Allison also pointed out that in studies of chemotherapeutic attacks on cancer it has been found that the animals maintained on well-balanced diets are better able to withstand larger doses of chemicals, and thus improve the chance of cure, than animals on poorly balanced diets.

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Twitchell's Caramel Color imparts a rich color to food products . . . ranging from a light tan to dark brown. Leading food processors use this natural color. It is made entirely from dextrose, under controlled conditions.

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- Dry Cake Mixes • Bouillon Powders
- Powdered Coffee and other beverages
- Powdered Gravy Seasonings

Write for Sample!

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CRESTMONT & HADDON AVES. • CAMDEN 4, N.J.

In concluding, Dr. Allison cautioned against diet fads and said that it was the food technologist who can best help translate the findings of the experimental nutritionist into new food products that the public needs and demands. The food technologist can be instrumental in an important way in improving the nutrition of all consumers.

AUSTRALIA SOUTHERN . . .

SEVENTH ANNUAL CONVENTION

The Southern Section was host at this year's Convention, held at "Erskine House" on the Great Ocean Road, at Lorne, 86 miles from Melbourne from Wednesday, 1st May to Saturday, the 4th.

The Convention was officially opened by Mr. K. Brennan, Chairman of the Victorian Commission of Public Health.

The technical programme included:

"New Trends in the Manufacture of Chocolate and Confectionery," J. Cusack, MacRobertsons.

"Control and Prevention of Insect and Rodent Infestation in Food Industries," K. Downes, Houghton & Byrne.

"Overseas Developments in Bread Manufacture," E. Bond, Bread Research Institute.

"Emulsifiers & Stabilisers in Processed Foods," D. Brown, Kraft Foods.

"Problems Associated with the Manufacture of Tin Plate," C. L. Francis, B.H.P.

"The Future of Plastics in High Speed Low Cost Packaging," D. G. Keith, I.C.I.A.N.Z.

"Flavour Retention in Processed Foods," J. Kefford, C.S.I.R.O.

"Artificial Flavours," Mr. Kinsey, W. J. Bush & Co.

"Recently Developed Laboratory Techniques in the Study of Food Flavours," D. Forss, C.S.I.R.O.

AUSTRALIA NORTHERN . . .

Australia Northern Section. Membership rose to 120 members during 1956–57. During this year eight general meetings were held. Three of these took the form of visits to places of interest such as the Snowy Mountains Authority area, which is similar to the T.V.A. scheme in the U. S. For four of the meetings lectures were arranged. In March the speaker was Mr. C. Kenna, a lecturer in Applied Psychology at the University of Technology. Mr. Kenna presented a paper entitled "Taste! What It Is, and How It Is Assessed." At the end of this meeting it was suggested that a series of lectures on taste testing be held at the end of 1957. These lectures are being arranged by Professor J. Clark at the University of Technology.

The annual general meeting was held on June 4 in the Foods School, East Sydney Technical College. The speaker for the night was Dr. J. M. Gregory, Head of the Radioactive Isotope Division of the Australian Atomic Energy Commission. Dr. Gregory spoke on

(Continued on page 32)

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Retains brightness of natural color, retards unsightly oxidation, enhances natural condiment flavors.

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(Continued from page 30)

"Radioactive Isotopes: how they can help the Food Industry." The paper was followed by a buffet dinner prepared and served by the students of the Foods School.

AMES . . . .

The Section's May meeting was held in the Memorial Union, Iowa State College, Ames, Iowa with 60 members and guests attending the luncheon and afternoon meeting. Dr. Paul Hartmann, Department of Bacteriology, was moderator for the program which included talks by Mr. Joseph Durham, Food and Drug Officer, Minneapolis District, on "The Use of Food Additives," Professor E. R. Baumann, Iowa State College, on "Sanitary Problems in Food Industries," and Mr. Gerald Reed, Red Star Yeast and Products Company on "Enzymes in Relation to Food Processing." Mr. Richard Carey, Chairman, presided at the business meeting.

The following officers were elected:

Chairman: Dr. John Ayres, Iowa State College.

Chairman-Elect: Mr. Chester B. Stevens, Independence Produce Company, Independence, Iowa.

Secretary-Treasurer: Dr. Frances Carlin, Iowa State College.

Councilor: Mr. Glenn Cooper, Rath Packing Company, Waterloo, Iowa.

At the March 15th luncheon held at the Memorial Union, Iowa State College, the Section was addressed by Dr. George F. Garnatz, then IFT President, who gave an informal talk on the national organization.

The first speaker on the afternoon program, R. W. Callaghan, General Mills, Minneapolis gave a talk, well illustrated with slides, on "Engineering Problems in the Development of a New Product." Then Dr. J. E. Hodge, Northern Regional Research Branch, Peoria, Illinois gave an excellent paper on "Non-enzymatic Browning in Foods and Feeds." The third talk on "Use of Antibiotics in Food Preservation" was ably given by Dr. C. L. Wrenshall, Pfizer and Company, Brooklyn, New York. Then Dr. George Garnatz, Director, Kroger Food Foundation, Cincinnati, Ohio, gave a most interesting discussion of "Consumer Testing" in which he described the methods used by Kroger Company in gauging consumer acceptance.

At the business meeting, Dr. John Ayres, Chairman, appointed Dr. Emerson Bird, Iowa State College, as chairman of the membership committee; Mr. Dean Montgomery, Decker Company, Mason City, as chairman of the nominating committee; and Dr. Earl Hammond, Iowa State College, as chairman of the program committee.

OHIO VALLEY . . . .

Dr. H. D. Brown Retires from The Ohio State University. Dr. Howard D. Brown, capable teacher and technical writer, has retired from his professorship (horticulture) at The Ohio State University, but as Research Coordinator for the National Potato Chip Institute, will by no means cease his professional activities.

Co-author of two books, Dr. Brown's name appears on eighty-five scientific publications. At the meeting of the Ohio Valley Section, Institute of Food Technologists, Dr. Brown was presented a bound copy of most of his writings by the students of the Horticultural Products Society. Entitled *The Writings of H. D. Brown,* the first page of the volume contains the following inscription: "As a small token of our sincere appreciation for your many generous services as an educator and as a true friend of all students, we, the students of the Horticultural Products Society, the Ohio State University, present to you this collection of some of your many publications."

Dr. H. D. Brown, retiring professor of horticulture at Ohio State University, is presented a bound copy of his writings by Karl A. Hirzel, Jr., President of the Horticultural Products Society. *Photo by R. P. Evans*

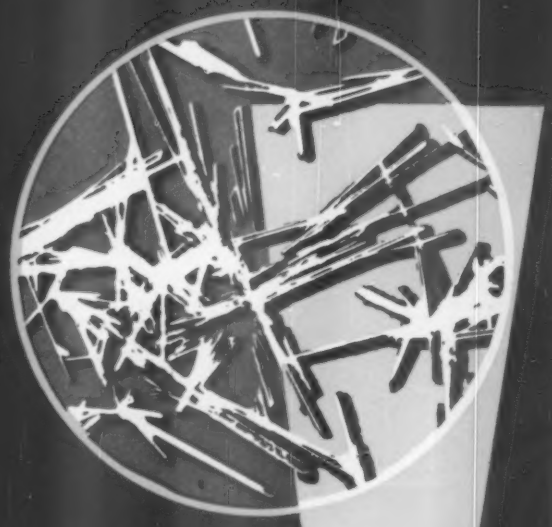
Dr. Brown was guest of honor at the O. S. U. Alumni Luncheon held at the IFT meeting in Pittsburgh in May. He has received many other awards.

Born on a farm near Lexington, Illinois, Howard D. Brown received his B.S. and M.S. degrees from the University of Illinois and his Ph.D. degree from Michigan State College. A member of Sigma Xi, Phi Sigma, Phi Tau Sigma and Gamma Sigma Delta honorary societies, H. D. is a Mason and member of Alpha Gamma Sigma, a professional fraternity.

He belongs to scientific organizations such as the American Association for the Advancement of Science, American Society of Horticultural Science, American Society of Plant Physiologists, Institute of Food Technologists, and the Ohio Academy of Science. His memberships in grower organizations include the Vegetable Growers Association of America, Inc., Ohio Vegetable and Potato Growers Association, American Farm Bureau Federation, the Columbus Vegetable Growers Association and he is an honorary member of Ohio Locker Operators Association.

His research includes studies on vegetable pruning and breeding, characteristics of the potato, for example,

(Continued on page 35)



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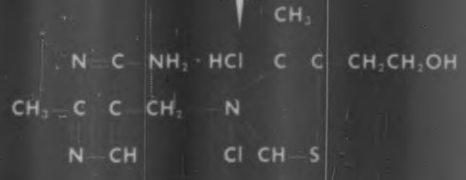

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(Continued from page 32)

apical dominance, processing of vegetables and fruits, hydroponics, nutrition, storage, soil fertility tests, trace element studies, and varietal susceptibility of cucurbits (members of the gourd family) to DDT injury.

His success as an educator, author and research worker is the product of human patience, intelligence and skill. He maintains that "knowledge is something to be utilized and, therefore, valued as a possession, but that original thinking should be prized beyond all else." The Ohio State University will truly miss the services of Dr. H. D. Brown.

PERSONNEL

DR. CARL R. FELLERS HONORED

DR. CARL R. FELLERS, retiring head of the Department of Food Technology, University of Massachusetts, Amherst, was honored on May 14 by more than 100 of his friends and former students at a testimonial luncheon given during the 1957 Institute of Food Technologists Annual Meeting in Pittsburgh, Pennsylvania. The testimonal was arranged by a group of former students. Dr. Fellers was presented with an inscribed silver tray and a check.

Dr. Carl R. Fellers (left), retiring head of the Food Technology Department, University of Massachusetts, receives from Dr. R. E. Morse (right) a silver tray, token of appreciation from former students.

The many accomplishments of Dr. Fellers and the great progress made by the Department of Food Technology at Amherst under Dr. Fellers' guidance were cited by Dr. Walter A. Maclinn, a former student, now head of the Food Technology Department at Rutgers University in New Jersey. About 500 students have studied under Dr. Fellers in his years at Amherst. They have gone out from there all over the world and their contributions are recognized as a very significant contribution to the field of food preservation and the feeding of man.

Dr. Fellers, author of over 200 scientific publications, has achieved many honors in his illustrious career, in cluding the Babcock-Hart Award by the Institute of Food Technologists in 1950. He is listed in *Who's Who* and in *American Men of Science*. He is a past President of the Institute of Food Technologists and was one of the eight founding fathers when the organization was started in 1937.

Through the years Dr. Fellers has been active in the military. During World War I he worked as a Public

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Health Officer during the influenza epidemic and for his efforts received the Medal of Merit. During World War II he served as coordinator of food supplies for the troops in the South Pacific and was awarded the Bronze Star for this effort. He has remained in the Reserves, commanding the Research and Development Unit in the Amherst area. He holds the rank of Lt. Colonel.

Dr. Fellers is one of the true pioneers in the conversion of the food processing industry from an art to a sound science. His career stretches back to the early days of canning salmon in the Pacific Northwest. During this period he was on the faculty of the University of Washington. He has also been on the technical staff of the National Canners Association and the Hills Brothers Company. He holds many patents for the commercial processing of food. His great technical and administrative talents have also been utilized on the Advisory Boards and Boards of Directors of many food companies, including the Blue Channel Corp. of North Carolina.

Dr. Fellers is married to the former Josephine Sanders. They have eight children and six grandchildren. His future plans call for a bit of fishing at his Cape Cod home, but he will retain an active interest in the Food Processing Industry.

Appointment of DR. BERNARD L. OSER, Director of Food Research Laboratories, Inc., as Scientific Editor of the Food Drug Cosmetic Law Journal has been announced by Mr. Charles Wesley Dunn, Chairman of the Journal's Editorial Advisory Board. In making the announcement, Mr. Dunn pointed out that Dr. Oser's counsel would enable the Journal to broaden its reporting and interpretation of the scientific and technical aspects of the law in the field of food, drugs, and cosmetics.

Dr. Oser has substantial editorial experience, having served on the editorial boards of *Analytical Chemistry*, FOOD TECHNOLOGY, and the *Journal of Agricultural and Food Chemistry*. As advisor on nutritional and toxicological problems to many corporations, Dr. Oser has an intimate knowledge of the ramifications of the Food, Drug, and Cosmetic Act.

The Quartermaster Food and Container Institute for the Armed Forces presented MR. PHILIP P. GOTT, President, National Confectioners' Association of the United States, an Award of Appreciation at the annual meeting of the Research and Development Associates, recently held in Richmond, Virginia.

The citation presented by Colonel John D. Peterman, U. S. Army, Commandant of the Quartermaster Food and Container Institute, Chicago, Illinois, reads as follows:

To: Philip P. Gott

"For your energetic and unselfish assistance to the Quartermaster Corps in the fulfillment of its mission, for your response at a moment's notice in providing expert counsel and nationwide industry cooperation needed to solve difficult problems relating to that mission, and for contributing time, thought and services to the coordination of all activities of mutual concern, specifically in the area of research and development leading to better confectionery items in the military supply system, this certificate of achievement is awarded. Your long record of support of the Quartermaster Corps has, without doubt, been accompanied by personal sacrifices which you have willingly made in behalf of industrial preparedness."

This certificate was signed by Dr. Donald K. Tressler, Scientific Director and by Colonel John D. Peterman, Commandant.

BOOKS . . .

ADVANCES IN FOOD RESEARCH. Vol. VII. Edited by E. M. Mrak and G. F. Stewart—404 pp.; including author and subject index. Academic Press, Inc., N. Y., N. Y., 1957.

This latest volume of *Advances in Food Research* is, like its predecessors, a collection of monographs, not an annual review of current developments in the broad field of food research. The virtues of this plan of organization become increasingly apparent as each new volume appears, and the series already provides an impressive perspective of the field. In contrast with the periodical review, these articles present their information in a concentrated and organized form. The accent, of course, is on new knowledge, but enough of the old is reviewed to place the new in perspective.

The present volume has seven chapters: The Profile Method of Flavor Analysis, Jean F. Caul; Spoilage of Fish and Its Preservation by Chemical Agents, Yukio Tomiyasu and Buhei Zenitani; Water Relations of Food Spoilage Microorganisms, W. J. Scott; Chlorine in Food Plant Sanitation, Walter A. Mercer and Ira I. Somers; Freeze-Drying of Food Products, J. C. Harper and A. L. Tappel; Gelatin, Bernard Idson and Emory Braswell; Licorice, C. Nieman.

Flavor Analysis by the Flavor Profile Method

The flavor profile method is presented by Caul against a background, briefly discussed, of other sensory methods such as difference tests. The profile method itself is fully described as to basic concept, selection, testing, and training of panels, testing techniques, and evaluation of results. Literature references are skilfully interpolated and do not detract from the continuity of the exposition.

Prevention of Fish Spoilage

Tomiyasu and Zenitani are somewhat more diffuse in their chapter on spoilage of fish and its prevention by chemicals. Starting with the types of bacterial flora, they discuss the nature and indices of degradational changes, both generally and with relation to species. Conversely, criteria and measures of freshness and

(Continued on page 42)

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and other natural flavors

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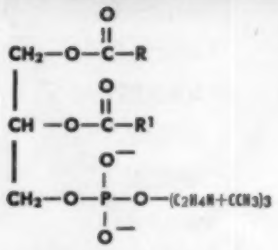

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Printing Inks—reduces grinding time, promotes better wetting and dispersion of pigments.

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Skin Lotions, Cosmetics, Beauty Soaps—softens and soothes skin, reduces irritation, increases cleansing power, stabilizes and improves lather.

Gravies-Sauces—prevents fat separation.

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SELECTED ABSTRACTS

(Continued from page 380d)

from 5 mg. per g. of coconut oil to an av. of 270 mg. per g. of wheat germ oil), (3) methods of isolating tocopherols from wheat germ oil, and (4) chem. and phys. properties, and detn., of the tocopherols.

FLAVORS AND FLAVORING

Flavors in foods—a cumulative review.

HENICH, A. S. (Quartermaster Food and Container Inst. for the Armed Forces, Chicago). *Food Research, 22,* 110–15 (1957).

As a result of the recent flavor conference held in Chicago, running reviews of the findings coming out of current flavor work will be published periodically in Food Research. This is the first review dealing with chemical aspects, testing and physiology of flavor.

FRUIT JUICES

Studies on the nutritive value of yeast fortified drinks.

RAMACHANDRA RAO, T. N. *Bull. Central Food Technol. Research Inst., Mysore, 5,* 353–4 (1956).

Dried baker's yeast was added to apple, orange and tomato juices, in addn. to various syrups. Good retention of the thiamine, riboflavin and nicotinic acid contents of the syrups was noted after 4 months. Studies on the fruit juices are still in progress.

MEAT AND FISH

Deterioration of dehydrated meat during storage. I. Non-enzymic deterioration in absence of oxygen at tropical temperatures.

SHARP, J. G. (Low Temp. Research Sta., Downing Street, Cambridge, England). *J. Sci. Food Agr., 8,* 14–20 (1957).

The deterioration appears to be due to a typical carbonyl-amino browning reaction. The effects of moisture content and temp. on the changes have been studies. The characteristic bitter, burnt flavors of stored dehydrated meat are produced only by reaction with the nonprotein fraction. The reaction can be inhibited entirely by storage in *N* contg. 500 p.p.m. of sulfur dioxide or by removal of the reducing sugar and glucose-6-phosphate by fermentation with high concns. of yeast. Partial inhibition is achieved by fermentation of the free sugars only, by lower concns. of yeast or by oxidation of the free glucose only, by glucose oxidase.

MILK AND MILK PRODUCTS

Biochemical aspects of cheese ripening.

HARPER, W. J., AND KRISTOFFERSEN, T. (Ohio State Univ., Columbus). *J. Dairy Sci., 39,* 1773–5 (1957).

A general scope of the changes taking place in cheese during ripening is presented. Specific changes as they occur in each variety of cheese will be discussed in later articles.

ORGANIC CHEMISTRY

Hydrolytic behavior of certain branched peptide derivatives of lysine.

THEODOROPOULOS, D., AND CRAIG, L. C. (Rockefeller Inst. of Medical Research, N. Y.). *J. Org. Chem., 21,* 1376–8 (1956).

A no. of peptide derivs. of lysine with both basic groups covered in peptidic linkage were synthesized. Hydrolysis expts. have shown that the ε peptide linkage is unusually resistant to hydrolysis. Even an aspartyl residue on this position was difficult to hydrolyze.

PATENTS

Frozen pineapple product.

FELTON, G. E. Assignor to Hawaiian Pineapple Co., Ltd. U. S. 2,785,076, March 12, 1957.

A frozen pineapple product contg. a stabilizing agent selected from the group consisting of $SnCl_2$ and $SnSO_4$ whereby the development of off-flavors during frozen storage is inhibited.

Method of making high-protein food products.

DUDMAN, R. K. Assignor to Swift & Co. U. S. 2,785,069, March 12, 1957.

Manufacture of synthetic food products from edible man-made protein fibers the improvement which comprises: forming a bundle of such fibers, which fibers are free from extraneous binders; subjecting the fibers to the action of heat and external pressure; and continuing the influence of the heat and the pressure until fusion of the fibers and the bundle takes place.

Method and apparatus for producing meat product.

CONDON, H. M. Assignor to Grand Duchess Steaks, Inc. Can. 538,406, March 19, 1957.

A process of treating meat which comprises the steps of providing a block of raw meat in substantially hard frozen state throughout, slicing from the hardened block relatively thin flakes of meat, applying heat to the flakes for a predetd. length of time to soften the same, compressing a multiplicity of the softened flakes into a compact integrated mass in which the softened flakes are thereby substantially impalpable in the mass, and freezing the compacted mass to hardened state throughout.

RECENTLY ELECTED MEMBERS OF IFT

Rafael Alvargonzalez
Jorge Juan 91
Madrid, Spain

Joyce Barger
Whirlpool Corp., Res. & Dev.
300 Broad St.
St. Joseph, Mich.

J. B. Batdorf
Hercules Powder Company
Research Center
Wilmington, Delaware

John J. Buchanan
Continental Can Co., Inc.
1350 W. 76th St.
Chicago 20, Ill.

Mohammad S. Choudhry
24 Cottonham Ave.
Kensington, N.S.W., Australia

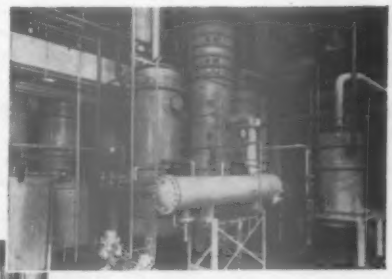
(Continued on page 40)

SOLUBLIZED *Pepperoyal*®

Hi-Fi Flavor

In seasonings, as in recorded music, "HI-FI" denotes a definite and enjoyable difference in quality.

Compare Griffith's Solublized PEPPEROYAL with any soluble pepper. Compare it for purity of flavor! . . . for potency of flavor! . . . for uniformity of flavor! You'll find the flavor of PEPPEROYAL exceptional—constantly and exclusively "HI-FI" in quality. That's an important advantage to you as a user.



"High Fidelity" Flavor naturally comes from prime quality spices. But, its real distinctiveness originates here with The Griffith Laboratories' exclusive process of controlled flavor extraction.

THE *Griffith* LABORATORIES, INC.

CHICAGO 9, 1415 W. 37th Street
NEWARK 12, 37 Empire Street
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SHEFTENE

BALANCED MILK PROTEINS

COMPLETE NUTRITIONAL SUPPLEMENTS . . .

RICH IN **LYSINE**

WITH ALL 8 ESSENTIAL AMINO ACIDS IN PROPER BALANCE

SHEFTENE Milk Proteins added to your food products give that extra plus in nutritive value.

The fact that the SHEFTENES provide *all 8 essential amino acids in proper balance* . . . with an abundance of Lysine . . . assures you of the best in quality of protein that can be built into your bakery products, flour, cereals, infant and geriatric foods.

SHEFTENE Milk Proteins are wholesome, edible products of high-quality, balanced protein content, capable of supporting growth and maintaining nitrogen equilibrium.

With 60 years of leadership in natural milk derivatives . . . including 30 years as leading producers of milk proteins . . . SHEFFIELD CHEMICAL is recognized as MILK PROTEIN HEADQUARTERS, your greatest and most reliable source of milk proteins in America today.

THE SHEFTENE SERIES

SHEFTENE C2 Edible Casein Flour (soluble form), and SHEFTENE C2 Edible Casein . . . to improve nutritive value of bakery products, flour, cereals.

SHEFTENE Calcium Caseinate . . . for supplementation of bakery products, flour, cereals; pharmaceutical, infant food and dietetic preparations.

SHEFTENE 60 . . . an excellent oral supplement for dietary foods and geriatric diet preparations.

THESE SHEFTENE PRODUCTS ARE AVAILABLE IN QUANTITIES TO MEET YOUR REQUIREMENTS

We welcome every opportunity to show you how SHEFTENE Milk Proteins can increase the nutritive value of your products. Write or phone our Technical Sales Dept.

ASK FOR FREE SAMPLES AND TECHNICAL DATA

SHEFFIELD CHEMICAL
Norwich, N. Y.

A DIVISION OF NATIONAL DAIRY PRODUCTS CORPORATION

(Continued from page 38)

Ben D'Addario
Minute Maid Corp.
488 Madison Ave.
New York 22, N. Y.

James M. Doty
1435 Clay St.
P. O. Box 7474
No. Kansas City 16, Mo.

James R. Fleming
Kansas State College
Dept. of Flour & Feed Mill. Indus.
Manhattan, Kans.

John P. Grattan
7524-11th Ave.
Brooklyn 28, N. Y.

Harold Gray
7903 Barlum Dr.
Indianapolis 20, Ind.

Lawrence E. Gray
Food Machinery & Chemical Corp.
Florida Division
Lakeland, Fla.

Martin P. Hanley
Sokol & Company
241 E. Illinois St.
Chicago 11, Ill.

Robert L. Hicks
Carnation Co.
8015 Van Nuys Blvd.
Van Nuys, Calif.

Eugene A. Huber
5920 Minnetonka Blvd.
St. Louis Park, Minn.

R. H. Jenkins
Hercules Powder Co.
332 S. Michigan Ave.
Chicago 4, Ill.

Mary B. Johnson
American Inst. of Food Distribution, Inc.
420 Lexington Ave.
New York, N. Y.

Ives V. M. Kerckx
Compagnie Liebig
Meir 59
Antwerp, Belgium

Andrew W. Martin
3 Burley St.
Lane Cove
N.S.W. Australia

L. J. Mather
Bryant Bros. Pty. Ltd.
Herbert Street
St. Leonards, N.S.W., Australia

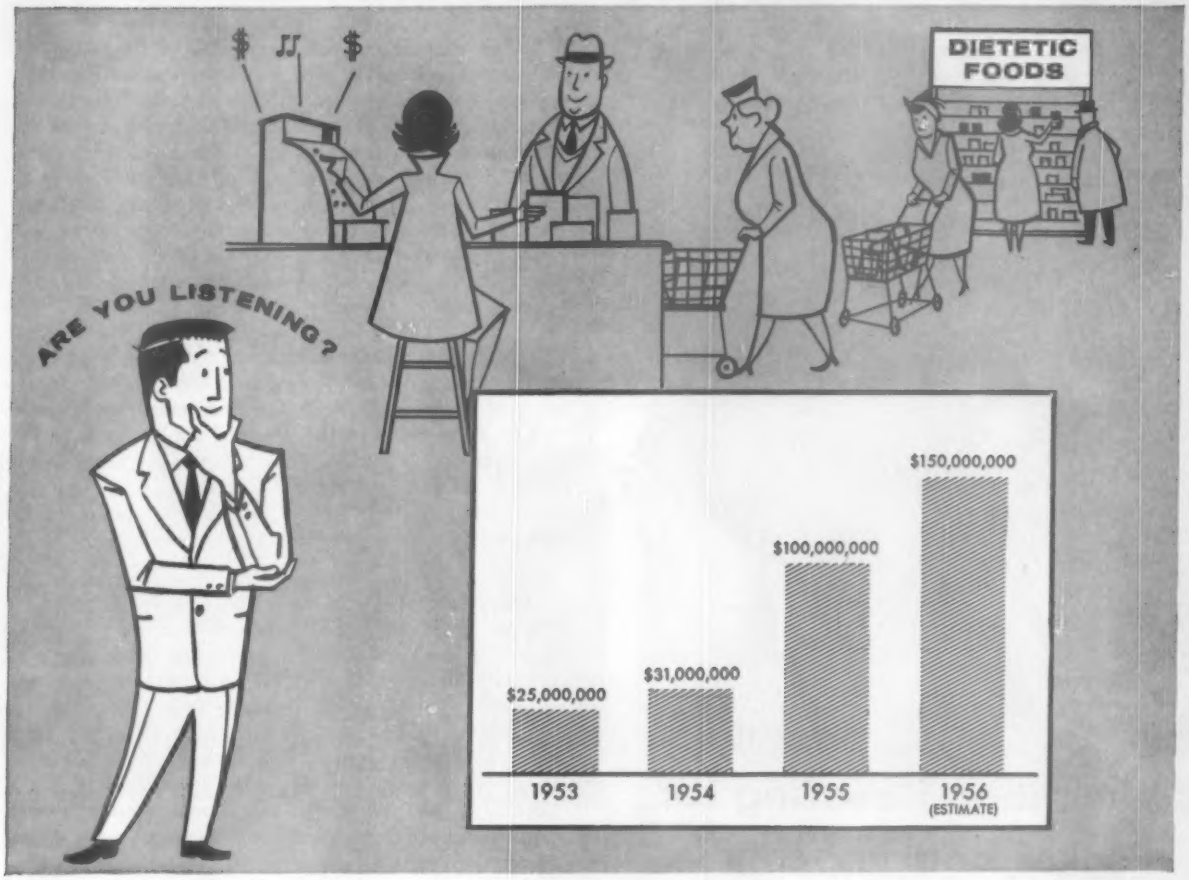
Peter W. McLaren
Gillespie Bros. Ltd.
Union St.
Pyrmont, N.S.W., Australia

Taylor A. McLemore
Southern Util. Res. & Devel. Div.
1100 Robert E. Lee Blvd.
New Orleans 19, La.

(Continued on page 50)

Dietetic Foods-

a $150 million business and still growing



Cylan® —Du Pont's non-caloric sweetener

CALCIUM & SODIUM CYCLAMATE

can help you get a share of this expanding market

Diet-conscious consumers are spending millions for low-calorie foods and beverages. And they're ready to buy an even wider variety of diet-styled products that have a delightfully natural taste. Formulating with Du Pont "Cylan" will give your dietetic products just what your customers are looking for and give you a profitable share of a market that is growing larger every shopping day.

"Cylan" gives dietetic foods and beverages a deliciously sweet taste, without adding calories. It is stable, economical and easy to use.

Join the processors who have found that their dietetic products sweetened with "Cylan" have the elegant taste that builds popularity for their brands.

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BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

E. I. du Pont de Nemours & Co. (Inc.) FT-77
Grasselli Chemicals Dept., Room 4161-D, Wilmington 98, Del.
I am interested in ☐"Cylan" Calcium ☐"Cylan" Sodium
Please send me: ☐ An inspection sample ☐ A working sample
☐ Information for making dietetic_____
Name_____
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For that "just-picked" real fruit flavor

FRIES & FRIES

RASPBERRY

An ideal imitation flavoring for cakes, cookies, candies and soft drinks . . .

The Fries and Fries laboratories specialize in creating flavors to meet your specific needs.

Contact us and let us show you why our fine flavorings are used in leading products found on every supermarket shelf.

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NEW YORK .....418 E. 91ST STREET
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BOOKS

(Continued from page 36)

quality of fish receive attention. Some 20 chemical agents used or proposed for fish preservation are listed, ranging from chlorine compounds to antibiotics. The writers feel that an important subject for further research is ascertaining the factors influencing rigor mortis and its duration.

Food Spoilage Organisms and Water

Scott's chapter on water relations of food spoilage microorganisms covers both the theoretical and practical aspects of the water requirements of molds, yeasts and bacteria. Much of the theoretical treatment is built on the concept of water activity of the medium or substrate, one which has served to unify the work of many investigators. Application of the principles to fresh, dried, concentrated, frozen and canned foods are shown. Scott considers that many more facts are still needed regarding the water requirements of food spoilage organisms.

In-plant Chlorination

Mercer and Somers write from extensive experience in the application of chlorine and chlorine compounds to food plant sanitation. The theoretical background is well developed, and the practical applications, mostly in canning, cover in-plant chlorination of water supply as well as local chlorination of re-used water. A picture emerges of a powerful tool for improved plant sanitation, water economy, and control of spoilage.

Freeze-drying

The freeze-drying of food products is presented by Harper and Tappel as a method overcoming, wholly or in part, the various undesirable changes associated with ordinary high temperature or vacuum drying of biological materials. A description of methods and equipment is followed by the theoretical principles and quantitative aspects of freeze-drying. Applications to meats, poultry, fish, eggs, fruits, fruit juices, vegetables, milk, and beverages are described. Additional research needs pointed out are those relating to processing methods and to food products.

Gelatin

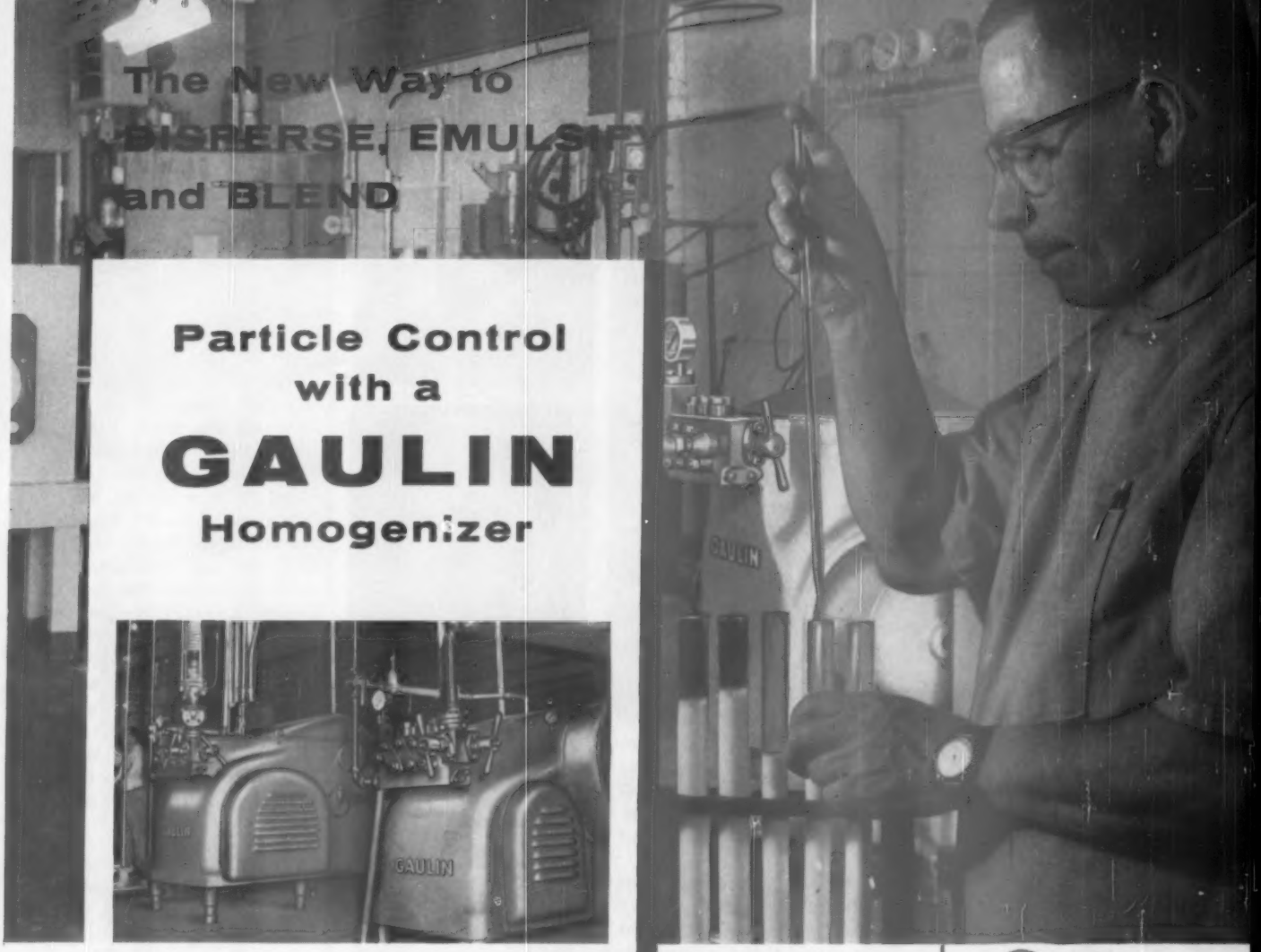
Gelatin is the subject of the longest chapter of the book, totalling, with bibliography, 104 pages. Idson and Braswell describe the industrial technology of gelatin manufacture, its biochemical origin, and give an impressive amount of information on its chemical and physical properties. The applications to foods and pharmaceuticals, and in photography and specialized industrial uses, are well covered.

Licorice

In the final chapter Nieman follows licorice from its botanical source to the ultimate use in pharmacology, confectionery, tobacco, and foods and beverages. Its use in pharmacology in particular is traced in an interesting historical sketch to the ancient Chinese, Greeks, and Romans. The various pharmaceutical preparations are described and their physiological action reviewed. Completing the chapter is a review of the chemistry of licorice constituents and available methods of assay.

Each chapter carries an extensive bibliography and both author and subject indices appear at the end of the book.

CARLOS A. GREENLEAF
Washington, D. C.



Particle Control with a GAULIN Homogenizer

What's the best method to disperse, emulsify or blend? It's all in Particle Control. No single piece of equipment will satisfy all requirements, so Gaulin offers three designs.

HOMOGENIZER works at high pressures, uses tremendous velocity and energy gradients to create extreme concentrated turbulence to produce more uniform, stable emulsions and dispersions.

SUB-MICRON DISPERSER handles pigments and other abrasive dispersions. S-M-D Valve uses the same hydrokinetic principles as Homogenizer to produce dispersions of ultimate fineness.

RE* COLLOID MILL is a highly advanced, two-stage design which provides continuous micrometer control for producing superior emulsions or dispersions. Operation is greatly simplified, maintenance negligible.

LABORATORY HOMOGENIZERS AND COLLOID MILLS are available on rental basis. Use them to explore the dramatic new Gaulin dimension of Particle Control.

PARTICLE CONTROL plus GTA — Gaulin Technical Assistance — is the key to new savings, better quality in your processing.

For complete data on the new RE* Colloid Mill — Ask for Bulletin C-57

Find out about all the things you can do with a Laboratory Homogenizer — Ask for Bulletin LH-55.

For technical data on Homogenizers and Sub-Micron Dispersers — Ask for Bulletins H-55 and SMD-55.

Manton-Gaulin offers complete research, laboratory and test facilities, plus 60 years' experience, to help you apply Particle Control for dispersions, emulsions and blends.

FREE! Ask for GTA and the Gaulin Library of Product Information . . . your best source for a low-cost solution to moving or mixing your product. Write or call today.

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MGT-15

FOOD INDUSTRY TOPICS . . .

. . . in the public interest

A New York City flavor manufacturer, van Ameringen-Haebler, Inc., has taken steps to safeguard more than 50,000 process specifications and aromatic chemical and flavor formulas from possible disaster. The records, which represent the results of 40 years' research in the company's laboratories, have been microfilmed and stored in vaults tunneled into a mountain in upper New York. Company officials pointed out that one of the major reasons they took this fire and catastrophe precaution is to provide assurance to customers who rely on the formulations for manufacture of their own products.

◆ ◆ ◆

"Diminishing incentive" is the most critical long-range problem of business and of the nation today, according to Crawford H. Greenewalt, president of the Du Pont Co. Speaking recently in New York City, Mr. Greenwalt took issue with "those patterns of thought which seem determined to abandon the very drive which has placed us on the road to great accomplishment."

"What an astonishing paradox we present," Mr. Greenewalt said. "We set high standards of achievement, yet, when the rewards of achievement are won, we reclaim most of them in the guise of taxation so that achievement becomes not only financially unattractive but an actual burden. We admire success, but penalize the successful; we admire talent, but penalize the talented."

He added, "I am afraid that too little thought has been given to the moral implications of taxing away 90% of one man's earnings so that another's tax might seem less unpalatable. I am afraid that the issue has been drawn too often along political rather than moral lines."

◆ ◆ ◆

The Refrigeration Research Foundation of Colorado Springs announces the awarding of the Samuel Cate Prescott Fellowship for 1957 to Mr. Sam R. Cecil of the Georgia Experiment Station, Experiment, Ga. Mr. Cecil is now doing post-graduate research in the Department of Food Technology at Oregon State College.

. . . the human element

Dr. Buell W. Beadle has been named manager of the chemistry division of Midwest Research Institute, Kansas City, Mo. Dr. Beadle, a member of a number of professional societies including the IFT, most recently was chairman of the department of chemistry and chemical engineering of Southwest Research Institute, San Antonio.

◆ ◆ ◆

Dr. Gail M. Dack, professor of microbiology at the University of Chicago and director of its Food Research Institute, has received the 1957 Pasteur Award of the Society of Illinois Bacteriologists. He was honored with the award, presented annually to an outstanding bacteriologist in the Midwest, for his research on the causes of bacterial food poisonings. Dr. Dack, an IFT member, also has received the Ricketts Prize and was the 1956 winner of IFT's Babcock-Hart Award, in recognition of his research contributions to food production and processing.

◆ ◆ ◆

Herbert N. Riley, a pioneer in the field of food technology, retired recently after nearly 45 years of continuous service with H. J. Heinz Co. He had been executive vice-president of the company since 1949, and he will remain a member of the Heinz board of directors, a post he has held since 1935. Mr. Riley was one of the founders of IFT, and has been active in the American Chemical Society and the National Canners Association for many years. H. J. Heinz II, company president, announced that the new Heinz Research Center will be dedicated to Mr. Riley in recognition of his contributions to food technology and corporate administration.

Herbert N. Riley

◆ ◆ ◆

Walter S. Barlow has been named director of quality control and product research for Southland Frozen Foods, Inc. In his new post, Mr. Barlow, an IFT member, will direct activities at Southland's four processing and freezing plants in Florida, New York, and Tennessee.

◆ ◆ ◆

Edmund F. Ball, president and chairman of the board of Ball Brothers Co., was elected president of the Glass Container Manufacturers Institute at a recent meeting of the Institute's board of trustees. **J. S. Heuisler,** president of the Maryland Glass Corp., was named first vice-president of GCMI, and **F. N. Dundas,** executive vice-president of the Dominion Glass Co., Ltd., became second vice-president of the Institute.

Edmund F. Ball

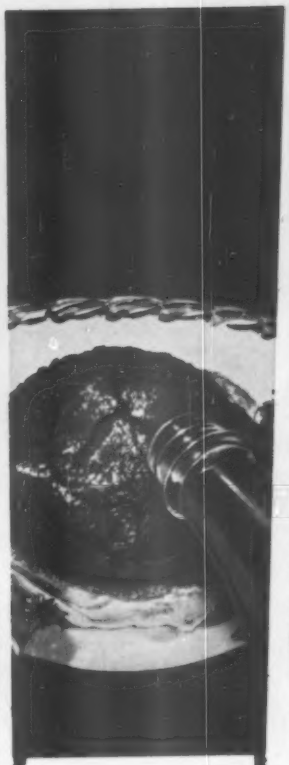
◆ ◆ ◆

Dr. Ernest Guenther, vice-president and technical director of Fritzsche Bros., Inc., New York, was scheduled to leave recently on a five-month tour to inspect spice and essential oil production in Africa.

(Continued on page 46)

IN BREAD

Assures complete, controlled fermentation, enhances flavor and aroma, gives even texture, uniform grain, maximum retention of softness, longer shelf life.



IN CATSUP

Preserves piquant tomato flavor, enhances delicate spice flavors, protects the rich red color of all tomato products.

IN FROZEN DESSERTS

Assures firmer, finer-grained ice cream, with rich butterfat flavor—prevents surface crusting and preserves true fruit flavor in sherbets and water ices.

IN CANNED FRUITS

Enhances true fruit flavor, protects natural color, stabilizes the good eating qualities of fruits—adds appetite and sales appeal.

CERELOSE

BRAND DEXTROSE

For technical assistance in developing improved food processing formulations, contact our nearest sales office or write:

CORN PRODUCTS SALES COMPANY, 17 BATTERY PLACE, NEW YORK 4, NEW YORK

(Continued from page 44)

His itinerary included Central and South Africa, Madagascar, the Comoro Islands and Reunion Island.

◆ ◆ ◆

James Kenny has been appointed field sales manager for the Atlas Chain & Mfg. Co., West Pittston, Pa. He formerly covered sales territory in the seven northeastern states for the company.

◆ ◆ ◆

Howard B. Smith, Jr., has been appointed sales engineer in the Middle Atlantic states for the process equipment division of Rodney Hunt Machine Co., Orange, Mass. Mr. Smith will work out of offices in Chester, Pa.

◆ ◆ ◆

Richard G. van Dyke has been named to organize a quality control and technical organization for South Coast Fisheries, Inc., Terminal Island, Calif.

. . . *things new under the sun*

New anti-sticking agents, said to increase the effectiveness, sanitation and economy of candy releasing operations by eliminating the use of dusting flour, have been introduced by Mallet & Co., 601 E. Gen. Robindon St., Pittsburgh 12. The new products are Nutrilease, a nutritive, all-vegetable compound, and Candeze. Both release agents were developed for use on cooling slabs, pans, trays and other surfaces from which batches of caramel, taffy or other sticky candy ingredients must be removed.

Nutrilease and Candeze are said to be odorless and tasteless and are protected against rancidity with permissible food antioxidants. They may be applied by hand or spray.

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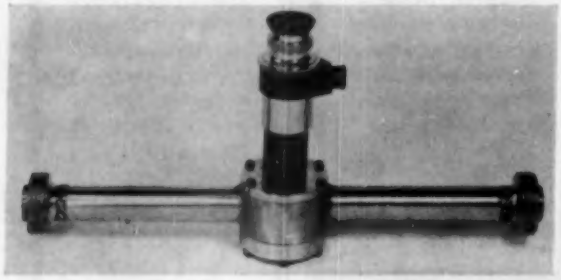


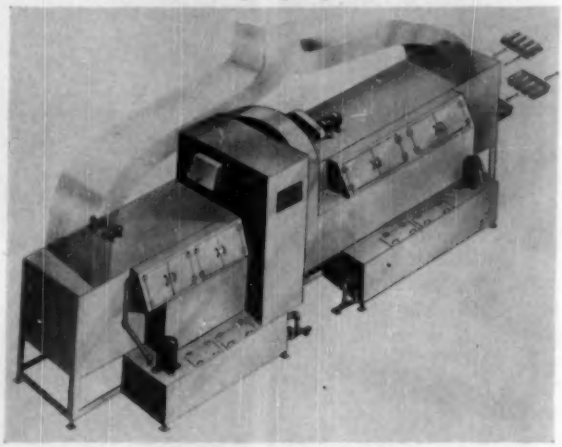
Epic, Inc., 154 Nassau St., New York 38, has been named U. S. distributor for the new series of B&S pipeline refractometers. The instruments are designed for continuous control of concentration of liquids, showing at all times the refractive index of the substance in the pipe without taking a series of samples.

According to the distributor, an unskilled operator can take the measurements, and once the unit is installed no adjustments are necessary. All parts contacting the product are of stainless steel; other materials are available for special applications.

The range of refractive index covered can be arranged as desired. In general, an accuracy of 0.0005 R. I. can be achieved and, when the instrument is fitted with a micrometer screw and magnifier, an accuracy of 0.0001 is possible with transparent liquids.

Available models are designed for use with transparent and dark or heavily colored substances, for flange-mounting on evaporators, and for high-temperature applications.

◆ ◆ ◆



A new type of bakery pan washer, Con-Jet, is said to meet high-speed pan washing and drying requirements and at the same time take less valuable floor space. An over-and-under conveyor system accounts for the saving in space and also permits all operations to be handled at one end of the machine. Pans fed into the machine are washed and rinsed on the upper level, then dried by gas-heated air as they return along the lower level. Conveyors may be connected to the machine to provide a completely automatic operation.

The Con-Jet Model CJ 36- by 6-in. WRD requires only 28 by 7 by 10 feet of space and can process 1,000 standard sheet pans per hour when operating at average conveyor speed. Bread pans can be cleaned at the rate of 25 per minute.

Further information can be obtained from Industrial Systems Co., Matawan 1, N. J.

◆ ◆ ◆

An advanced electronic system now is available for measuring and recording moisture content in a wide range of industrial products. Called the Sentry Custom continuous moisture detector, it is a unitized system with primary circuits contained in lightweight, replaceable drawers. Moisture selectivity curves range from 0 to 30% and moisture classification of moving material is governed by a single control. The console of the unit can be placed at any desired remote location.

Already widely used in the forest products industry to measure the moisture content of veneer and lumber, the detector is said to be applicable to such products as cereals, tobacco, bakery products and other materials handled on moving conveyors.

Complete information on the Sentry Custom can be obtained from Laucks Laboratories, Inc., 1201 Poplar Pl., Seattle 44, Wash.

◆ ◆ ◆

A new aid to laboratory technicians comes in the form of a remote control device for adjusting the air

(Continued on page 48)

Lift your sales to new highs with

FLAVEDOL®

Citrus Concentrates

by Givaudan

Universal and Uniform! Givaudan's FLAVEDOL CITRUS CONCENTRATES are a mixture of oils from various producing areas . . . *BLENDED* to give you maximum economy, strength, quality and distinctiveness of flavor . . . *CONCENTRATED* for maximum stability. Uniform from batch to batch in odor, taste and strength. Lime, lemon or orange—they are ideal, finished flavoring materials for gelatin dessert powders, hard candies, sherbets, Kola drinks and other beverages.

Flavedol Citrus Concentrates live up to Givaudan's world-wide reputation as a leading producer of *quality* products. We are proud to recommend our Flavedol Citrus Concentrates to you, and invite your inquiries.

Givaudan Flavors Inc.

330 West 42nd Street, New York 36, N. Y.

(Continued from page 46)

flow in fume hoods. Instead of having to reach inside the hood to adjust the air baffles, as in conventional hoods, an operator using the new device can make any necessary baffle adjustments with a control handle located on the front panel. Called the "Safe 'n Easy" remote control, the device can be operated with the safety sash open or closed, and is said to eliminate both lost time and the hazard of broken equipment and escaping fumes. The remote control feature is optional on fume hoods in the Steelab and Woodlab lines of laboratory furniture produced by Laboratory Furniture Co., Old Country Rd., Mineola, N. Y.

◆ ◆ ◆

Sheffield Chemical, a division of National Dairy Products Corp., has announced the availability of the Sheftene series of concentrated milk proteins for nutritional supplementation of cereals, flour, and pharmaceutical, infant food and geriatric diet preparations.

Products in the series are Sheften C2 edible casein flour (soluble form), Sheften C2 edible casein, Sheftene calcium caseinate and Sheftene 60. All four products are said to be high in protein content (up to 90%) and to provide all eight essential amino acids in proper balance. According to the company's technologists, an abundance of lysine in these Sheftent milk proteins makes them ideally suited as multiple amino acid food supplements, particularly in cereal grain products. The research division of National Dairy Products Corp. has reported a "biological" value of about 85% for these products.

A new brochure, "The Sheften Family of Milk Proteins," can be obtained by writing the company at Norwich, N. Y.

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

July 22–24	Seventy-fifth Annual Convention of the National Macaroni Manufacturers Association, Grand Hotel, Mackinac Island, Michigan
August 19–23	Gordon Research Conference on Food and Nutrition, Colby College, New London, New Hampshire
September 8–13	One hundred thirty-second National Meeting of the American Chemical Society, New York, N. Y.
September 30–October 2	Fall Meeting of the American Oil Chemists' Society, Netherland-Hilton Hotel, Cincinnati, Ohio
October 4	75th Anniversary Symposium of the New York State Agricultural Experiment Station, Cornell University, Geneva, New York. Subject: The Role of Agriculture in Future Society
October 9–11	Fourth Annual Symposium on High Vacuum Technology, Hotel Somerset, Boston, Mass.
October 14–16	Association of Official Agricultural Chemists, Shoreham Hotel, Washington, D. C.
November 18–December 9	Ninth Pacific Science Congress of the Pacific Science Association, Chulalongkorn University, Bangkok, Thailand

An open invitation is extended to readers of FOOD TECHNOLOGY to send in to the Editorial Office, 11606 South Bell Avenue, Chicago 43, Illinois notices of annual or national meetings of interest to food technologists.

The first shipment from the newly completed cellophane plant of the Film Div. of Olin Mathieson Chemical Corp. at Olin, Ind., is checked out by Ralph Heller (left), plant manager, and J. F. Stewart, manufacturing superintendent. The new plant, scheduled to be in full production this summer, will approximately double the company's capacity.

◆ ◆ ◆

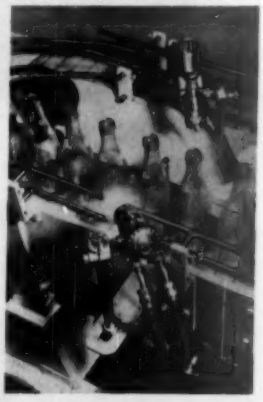
A Houston firm manufacturing oil-field equipment has recently found itself supplying valves to the food processing industry. An instant-coffee manufacturer in Houston found that a stainless steel, nonlubricated valve produced by Cameron Iron Works, Inc., meets the need for a valve that will not contaminate coffee with sealing lubricants.

Made of ASA 304 stainless steel body and bonnet, with 11-13 chrome stainless alloy plug and seat, the valve can be obtained in a range of sizes to fit connections from 1 to 14 in. It also is available in any specified alloy on special order to handle other types of effluent.

Details can be obtained from Cameron Iron Works, Inc., Box 1212, Houston 1, Tex.

◆ ◆ ◆

A new silicone protective treatment for returnable soft drink and dairy bottles has been developed by Dow Corning Corp. Called Syl-Gard 17, the treatment is said to reduce breakage by as much as one-half, make glass containers more resistant to abrasion and consequently keep them new-looking longer.



Syl-Gard 17 is a liquid concentrate, ready to be diluted with water. One 8-oz. bottle, mixed with water in an 8- to 15-gal. spray tank, is said to provide sufficient solution for a day's production on a single filling line.

Dow Corning says that Syl-Gard 17, applied to bottles each time they pass through the filling line, provides a non-oily silicone lubricating film that not only reduces abrasion but noticeably improves the gloss and attractiveness of the container. The product currently is available from dairy and beverage equipment distributors, who can also supply precision spray equipment especially designed for silicone application.

. . . *the literary corner*

A bulletin entitled "Koppers BHT Antioxidant" has been issued by the Chemical Div. of Koppers Co., 1450 Koppers Bldg., Pittsburgh 19. The bulletin describes the advantages of employing butylated hydroxy toluene as an antioxidant in both farm feeds and human foods. Copies of the 16-page brochure can be obtained by requesting Bulletin C-7-243 from the manufacturer.

Fermco Chemicals, Inc., has published Technical Bulletin No. 5 to describe Catalase FC, a concentrated aqueous preparation for the decomposition of hydrogen peroxide. The bulletin includes specifications, suggested applications in food processing and other industries, and detailed properties. Copies can be obtained from the company at 4941 S. Racine Ave., Chicago 9.

Two new laboratory reports discuss the preparation of clear solutions from various types of gum arabic. Report A-820-G2 describes Premium XXX grade, especially designed to produce high-clarity solutions for flavor emulsions or powdered concentrates. Report A-820-G3 explains how maximum clarity and freedom from natural insoluble matter may be attained, depending on the concentration of gum solution desired. Both reports are available from Morningstar, Nicol, Inc., 630 W. 51st St., New York 19.

Of special interest to food processors working with cocoa is a new bullein available from the Dairy Equipment Div. of Blaw-Knox Co., Mora, Minn. The bulletin describes the new Solubilizer, a device which performs a process of blending a powder or dry mix into a product that is easily wettable. Construction details, operating requirements and dimensional data for the machine also are included.

Solving machine maintenance problems by changing to automatic lubrication is the subject of a six-page illustrated reprint offered by Bijur Lubricating Corp. Written by an applications engineer, "Make Your Machines More Automatic" explains how automatic lubrication systems provide dependable performance in the packaging field. The reprint includes a chart showing lubrication applications in nine varied packaging operations. Copies of the reprint, Bulletin A-7, can be obtained by writing "Service," Bijur Lubricating Corp., 151 W. Passaic St., Rochelle Park, N. J.

A completely revised, 43-page bulletin—V-203, Rev. 1—covering the entire line of Rockwell-Nordstrom semi-steel valves, has been issued by Rockwell Mfg. Co. The new bulletin, which supersedes an earlier, 35-page edition, includes two full pages describing lubricants and lubricating methods, and large photos showing in detail the working parts of four principal types of valves. Copies may be obtained from the Meter & Valve Div., Rockwell Mfg. Co., 400 N. Lexington Ave., Pittsburgh 8.

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Of special interest to microscopists is the April 1957 issue of "Scientific Instruments," a quarterly bulletin published by RCA. Devoted to the electron microscope, its two main feature articles are "The Electron Microscope in a Cancer Hospital," illustrated with electron micrographs, and "The Circuitry of the RCA Electron Microscope." The bulletin is published by Radio Corp. of America, Front & Cooper Sts., Bldg. 15–1, Camden, N. J.

Ehret Magnesia Mfg. Co., Valley Forge, Pa., has published a bulletin covering its line of calcium silicate insulation for piping and process vessels. Included are specifications for the basic sizes of insulation, tabulations of physical properties, and graphs showing thermal conductivity.

A 24-page catalog on industrial filter paper has been published by the Eaton-Dikeman Co., Mt. Holly Springs, Pa. Illustrated with charts, photographs and diagrams, the catalog presents a concise review of filtration practice, explains how paper as a filtering medium helps solve laboratory and industry problems, and offers aid in selecting the proper grade of filter paper for scores of applications. Articles deal with such subjects as the separation of solids and fluids, industrial and laboratory filter papers, chromatography paper and bibulous paper.

Copies of the catalog, No. 357, can be obtained by writing direct to the company.

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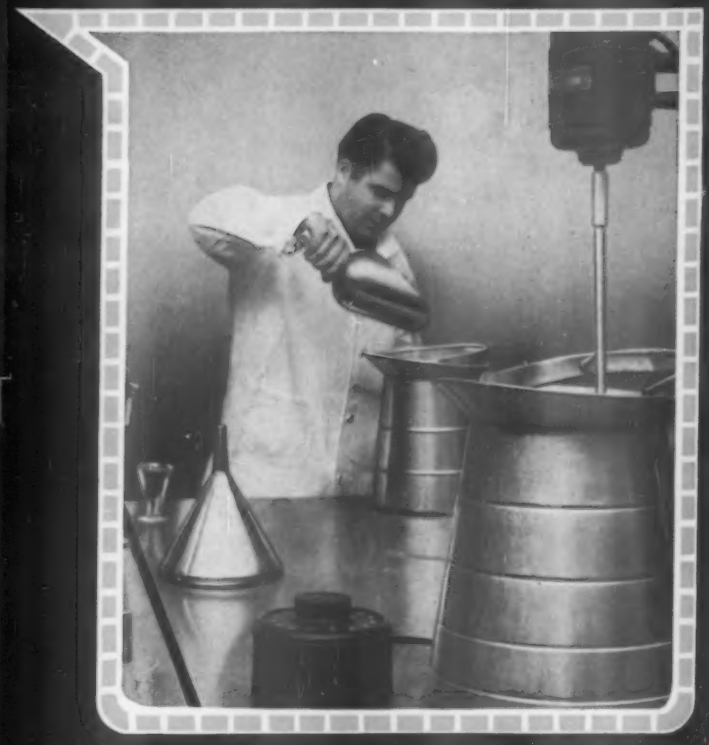

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